J86 Forestry

JOURNAL OF MAMMALOGY

VOL. 42 MAY 1961 NO. 2

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Journal of Mammalogy is published quarterly by the American Society of Mammalogists, 1041 New Hampshire St., Lawrence, Kansas.

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Second class Postage Paid at Lawrence, Kansas, U.S.A.
Made in the United States of America

JOURNAL OF MAMMALOGY

Published Quarterly by the American Society of Mammalogists

VOL. 42 20 MAY 1961 No. 2

SOURCE OF COLOR IN THE FUR OF THE GREEN RING-TAILED POSSUM

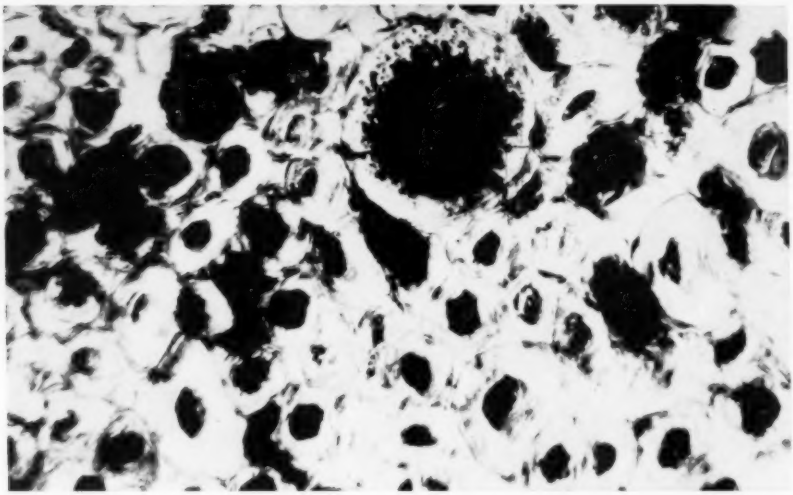
BY HOBART M. VAN DEUSEN AND E. I. STEARNS

ABSTRACT: The greenish-yellow color in the pelage of the ring-tailed possum, *Pseudocheirus archeri*, of Australia, was investigated microscopically. It was shown to be due to a blending of black, white and yellow colors, produced by the reflection of white light from the hairs in combination with the effects of varying amounts of melanin and xanthin in individual hairs.

For ten months during 1882 and 1883, a young Norwegian anthropologist and naturalist, Carl Lumholtz, lived with Australian aborigines in the Herbert River district of northern Queensland. One of the marsupials which was persistently hunted for food in the rain forest was the "toollah" or green ring-tailed possum, *Pseudocheirus* (*Pseudochirops*) *archeri*. Lumholtz preserved the skin and skull of a male possum which he sent to the Zoological Museum of the University of Christiania. Robert Collett (1884) based his description of this beautiful striped possum on Lumholtz's specimen. The nearest relative of *archeri* is the yellowish-green *Pseudocheirus corinnae*, which is widely distributed in the mid-mountain forests of New Guinea. This is another case of a mammal, presumably of New Guinea origin, which has reached northern Queensland and now occupies a relatively limited ecological niche (Tate, 1945, 1952).

In February 1948, Dr. Tate and the senior author collected two specimens of the green ring-tailed possum at Lake Eacham, near Yungaburra, Queensland. The hairs for the examination discussed below came from one of these, a male, A.M.N.H. No. 154373 (Archbold Collections). They were taken from the mid-dorsal region of the lower back. Collett's original description mentions the greenish coloration of the fur of *archeri* several times. This glistening greenish-yellow color is especially noticeable in direct sunlight. Our curiosity was aroused because of the rarity of green color in the pelage of mammals.

Color in nature is ordinarily caused by absorption, scattering, or interference of light. Green is often caused by selective absorption; for instance, chlorophyll is the dye (or pigment) which, by absorbing the red and blue constituents of white light and transmitting and reflecting only the green, produces the green color in vegetation. On the other hand, green is very seldom caused by green pigment in bird feathers, and we are not aware of the



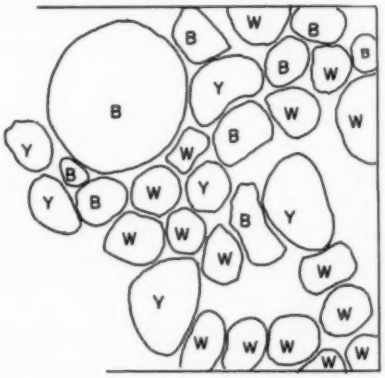


PLATE I

Cross-section of hairs of the green ring-tailed possum, *Pseudocheirus archeri*. Magnification, 800 ×. At right is a color key to a portion of the plate above: B, black; W, white; Y, yellow.

occurrence of green pigment in the hair of any mammal. The green color in the speculum of a duck is caused by light interference. The green in the painted bunting (*Passerina ciris*) is caused by a combination of scattering, which produces blue, and by absorption by the yellow dye xanthin, which produces yellow. The combination of yellow and blue appears green. Consequently it was thought to be of interest to establish the physical cause of the green color in the fur of the green possum.

Hair specimens of *Pseudocheirus archeri* were examined microscopically, both in longitudinal view and in cross-section. It was found that there were three colors present: white, yellow and black. The white was caused by the non-selective reflection of the incident light by the structure of the hair. The yellow was caused by xanthin which colored an entire portion of hair as if it

had been treated with a transparent dye. The black was caused by melanin which was distributed as if it were an insoluble pigment. When only a small amount of melanin was present in a portion of a hair, it was usually concentrated in the medulla, or central axis of the hair, and permitted the hair to appear white or light gray. When the melanin pigmentation was much more concentrated, it filled the hair and made it appear black.

Plate I is a photomicrograph of a cross-section of fur. Only one guard hair appears in this particular section. It is by far the largest in diameter. It will be noted that the hairs are either black (B), white (W), or yellow (Y), and that many of the white ones have a varying amount of melanin in the medulla. The color of some of these might better be described as light gray. Plate II is a photomicrograph of longitudinal views of five body hairs. The hairs vary in color along their length. Hair No. 1 has a series of ovate melanin granules uniformly distributed along the medulla, and appears light gray or white. Hair No. 2 is very similar to No. 1 as regards melanin content, but it is colored throughout with xanthin, which makes the hair pale yellow. Hair No. 3 is without xanthin and has a higher concentration of melanin; it appears gray, while No. 4 is filled solidly with melanin and is black. Hair No. 5 shows considerable color variation along the length included in the photomicrograph. The part where it crosses hair No. 4 is a bright yellow, having a high concentration of xanthin and practically no melanin. The part where it crosses hair No. 3 is very dark, practically black, and indeed the hair becomes black a short distance further along its length.

PLATE II

Longitudinal view of hairs of *Pseudocheirus archeri*. 800 ×.

To those unfamiliar with color mixing, it may be surprising that a mixture of black, white and yellow will appear green. Actually, it is impossible to produce a bright green with this combination, but the olive drab of tanks and trucks in World War II was generally produced by a mixture of black carbon, white titanium dioxide and yellow lead chromate pigments. The fur of the green possum, while truly green, is actually much closer to an olive drab than to a leaf green. If one is not acquainted with optical phenomena, it may seem strange that a mixture of colors will appear as a single color. Actually any checkerboard pattern, if placed so far distant that the squares are beyond the resolving power of the eye, will appear as a solid color. It is necessary to examine single hairs under a microscope in order to resolve fully the individual colors in the fur.

In this connection it would be of interest to examine the pelage of several other mammals with fur that appears greenish. One of these is *Funisciurus carruthersi* of the wet forests of Uganda and the Congo; another is the green guenon of West Africa, a member of the *Cercopithecus aethiops* group.

We wish to express our appreciation to Miss F. Gustafson of the American Cyanamid Company for preparing the hair samples and taking the photomicrographs.

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Archbold Expeditions, Dept. of Mammalogy, American Museum of Natural History, New York City; American Cyanamid Company, Bound Brook, N. J. Received 26 September 1960.

MORPHOLOGICAL FACTORS REGULATING FLIGHT IN BATS

By Thomas T. Struhsaker

Abstract: The role of certain morphological structures in the various modes of of flight occurring in 12 species of bats was studied. Techniques for determining the volumes of the entire body and of individual flight muscles, shapes of wings and surface areas of flight membranes were developed and appropriate measurements taken.

It was found that the surface areas of flight membranes, within groups having similarly shaped flight membranes, increase by approximately .66 times as the total volume of the body increases once. Futhermore, the surface area of the flight membrane per volume of the entire body is greater in those species with a lower aspect ratio than in those species with a higher aspect ratio. The total volume of all the ventral thoracic flight muscles increases approximately 1.16 times as the

total body volume increases once, irrespective of the shape of the flight membrane. The sum of the volumetric proportions of the pectoralis major and serratus magnus (inferior) remains approximately constant.

It is known that different modes of flight exist within the Chiropteran order, e.g., the fast, straight, enduring flight of *Tadarida*; the moderately slow and unmaneuverable flight of *Leptonycteris*; and the rather slow and highly maneuverable flight of *Myotis*. There are several morphological structures whose modifications may account for these differences in flight. Among the ways by which these modifications may be appraised are: the aspect ratio, which is defined as the ratio of wing span squared to the surface area of the wings; the ratio of the surface area of the wing to the volume of the total body; the ratio of the volume of total flight musculature to the volume of the entire body; and the ratio of the volume of individual flight muscles to the volume of total flight musculature.

I am grateful to the Undergraduate Research Participation Program of the National Science Foundation for financial support and to Rollin H. Baker of Michigan State University for supervision and counsel. Acknowledgment also is made to Phillip Clark, Henry Short and Peter Stettenheim, for their most helpful suggestions in this study.

Materials and methods.—The twelve species of bats used for this study were taken chiefly in Mexico, the specimens being from the collections of The Museum at Michigan State University. These species include: *Aëllo megalophylla* (Peters), *Choeronycteris mexicana* Tschudi, *Leptonycteris nivalis* (Saussure) and *Brachyphylla cavernarum* Gray of the family Phyllostomidae; *Desmodus rotundus* (E. Geoffroy-Saint-Hilaire) of the family Desmodontidae; *myotis lucifugus* (Le Conte), *Myotis velifer* (J. A. Allen), *Myotis thysanodes* Miller, *Pipistrellus hesperus* (H. Allen), and *Antrozous pallidus* (Le Conte) of the family Vespertilionidae; *Tadarida brasiliensis* (I. Geoffroy-Saint-Hilaire) and *Molossus nigricans* Miller of the family Molossidae. Most of the specimens were fixed in 10 per cent formalin and preserved in 70 per cent alcohol.

All volumetric determinations were done by water displacement in graduated containers, ranging in calibration from .01 cc for the smaller bats to 10 cc for the larger bats.

I felt justified in dissecting only the ventral thoracic flight muscles since these are the major muscles involved in the power stroke of flight and the ones most likely to demonstrate variations. The following muscles (nomenclature follows Macalister, 1872: 134–138) were removed and their volumes measured: pectoralis major (sternal and clavicular portions), pectoralis quartus, subclavius, serratus magnus (inferior and superior portions) and serratus anticus.

The surface area of the flight membrane was measured by tracing a single outstretched wing, including half of the interfemoral membrane, on a sheet of paper. This tracing was then outlined with a planimeter three different times. The average of these three measurements gave the surface area of one flight membrane in square centimeters. The length of the wing was measured di-

rectly by extending the wing laterally as far as possible and measuring from the wing tip to the point on the body perpendicular to an imaginary straight line from the elbow.

All 12 species were used in the studies involving surface areas of wings, shapes of wings and volumes of the entire body, whereas only 7 species (one specimen of each) were used in studies involving volumes of muscles.

Aspect ratios.—The aspect ratio is defined as the ratio of the wing span squared to the surface area of the wings. Since I was concerned only with wing shape, the ratio of the length of one wing squared to the area of the flight membrane on that side of the specimen was used. The interfemoral membrane was included, since its size varies with the species and no doubt plays an important role in lift, braking and turning. Not included was the width of the body, which also varies among species.

Upon determining the aspect ratios, including my alterations, it became evident that among the bats studied approximately three groups, based on the aspect ratio or the shape of the flight membrane, could be differentiated. These are: Group I—flight membranes short and wide, including *Myotis lucifugus*, *Pipistrellus hesperus*, *Antrozous pallidus*, *Choeronycteris mexicana*, *Brachyphylla cavernarum*, *Myotis thysanodes*, *Aëllo megalophylla* and *Myotis velifer*; Group II—flight membranes intermediate in length and width, including *Leptonycteris nivalis* and *Desmodus rotundus*; and Group III—flight membranes long and narrow, including *Molossus nigricans* and *Tadarida brasiliensis* (see Table 1).

It has been postulated and somewhat substantiated by other workers that long, narrow wings in bats and birds are indicative of rapid and/or sustained flight, while short, wide wings are indicative of slow and maneuverable flight. In using the term "maneuverable" flight, I include the phenomenon of hovering. My data appear to further substantiate this postule. Orr (1954: 207, 231), for example, described *Antrozous pallidus* as being able to hover momentarily when flying close to the floor of the laboratory. This ability is thought to be associated with its well-known habit of foraging close to the ground and frequently alighting on the ground to capture insect prey. Orr (1954: 203) also observed that *Antrozous pallidus* is easily outdistanced in flight by the free-tailed bat (*Tadarida brasiliensis*). Vaughan (1959: 26) described the flight of *Myotis velifer* as stronger and more direct than that of most other members of the genus, yet remaining highly maneuverable. He further observed that the flight of *Pipistrellus hesperus* is more erratic than that of *Myotis velifer*, although the flight of the latter becomes extremely erratic when pursuing an insect. From Table 1 it is seen that *Antrozous pallidus* is a bat of low aspect ratio and thus predicted to be a slow and maneuverable (erratic, hovering) flyer, readily outdistanced by a bat of high aspect ratio, such as *Tadarida brasiliensis*. Also Table 1 shows that *Myotis velifer* has a high aspect ratio and also is known to be less maneuverable and faster in flight than *Pipistrellus hesperus*, *Myotis thysanodes* and *M. lucifugus*. Therefore, it appears that, on

a comparative basis, one can predict, with fair accuracy, the modes of flight of bats from their relative aspect ratios. Thus, while it is difficult to form species divisions based on aspect ratios, because of the many intergrades, it can be said that those bats with a relatively high aspect ratio fly faster and straighter than those with a relatively lower aspect ratio.

Ratio of flight surface to body volume.—The shape of the flight membrane seems to be a major factor accounting for the differences in flight pattern. Owing to the lack of adequate information on the flying behavior of many species of bats, and the likelihood that structures other than the flight membrane itself aid in determining modes of flight, it seemed logical to study some of these other structures.

Storer (1954: 287–288), in his study of three hawks (accipiters), has emphasized a well-known mathematical principle that in objects of similar shape the surface area increases as the square of linear proportions and that the volume or weight increases as the cube of linear proportions. Accordingly, in winged creatures of similar shape, the surface area of the flight membrane increases by a factor of .66 as the volume of the entire body increases once (a 2:3 ratio). The relationship of the surface area of the flight membrane to the volume of the entire body is thus expected to be exponential. Therefore, measurements of these structures for each species of bat studied were converted to their logarithms from which a regression curve was established. In general, according to my data, the more closely bats are grouped with regard to the shape of their flight membranes, irrespective of their phylogenetic positions, the more nearly the above ratio is obtained. In Group I the slope is .587; however, when *Choeronycteris mexicana* is excluded, the slope is .601. There appears to be no significant difference in the aspect ratios

TABLE 1.—*Aspect ratios of twelve species of bats*

Group	Species (No. specimens)	Mean value of volume of body, ml	Mean value of fm in sq cm	Mean value of length of one wing, cm	Mean of aspect ratios (lw^2/fm)
I	*Antrozous pallidus* (1)	17.0	49.1	10.9	2.44
	Myotis lucifugus (1)	10.0	25.8	9.3	3.35
	Pipistrellus hesperus (2)	5.8	22.0	8.7	3.40
	Choeronycteris mexicana (6)	18.3	35.1	11.0	3.45
	Brachyphylla cavernarum (1)	55.0	77.4	16.5	3.51
	Myotis thysanodes (4)	10.0	32.8	11.2	3.81
	Aëllo megalophylla (2)	20.0	55.1	14.5	3.81
	Myotis velifer (20)	11.0	28.2	10.8	4.13
II	*Leptonycteris nivalis* (40)	37.5	49.0	15.1 (22)*	4.63 (22)*
	Desmodus rotundus (3)	49.3	52.9	16.2	4.99
III	*Molossus nigricans* (9)	36.1	32.8	14.0	5.97
	Tadarida brasiliensis (4)	12.2	19.8	11.4	6.57

* Only 22 *Leptonycteris nivalis* were used in determining the aspect ratio.
lw = length of one wing in centimeters.
fm = surface area of one flight membrane (one wing and half the interfemoral membrane).

of *Leptonycteris nivalis* and *Desmodus rotundus*. The value of .465 obtained for Group III differs appreciably from the expected .66 but probably no more than could be attributed to chance, when only two species are involved.

When the three groups, based on the shape of the flight membrane, are compared relative to the ratio of the surface area of the flight membrane to the volume of the entire body, it can be seen that bats having lower aspect ratios (slower in flight) have more surface area for the flight membrane than bats having higher aspect ratios (faster in flight).

Ratio of flight musculature to body volume.—Thompson (1942: 42–44) has related velocity to size in birds; in similarly shaped birds, as the linear dimensions are doubled the flight speed must increase by the $\sqrt{2}$ or 1.414 times. From this, Storer (1954: 289) has shown further that the capacity to do work, expressed as the mass of flight musculature, is proportional to linear dimensions to the 3.5 power. Therefore, the mass of flight musculature must increase 3.5 times as the mass of the entire body increases 3 times, i.e., a ratio of 1.16 exists, within similarly shaped animals, between the mass of flight musculature and the mass of the entire body. The relationship of the volume of the flight musculature to the volume of the entire body also is expected to be exponential. Consequently, measurements of these volumes for each species of bat studied were converted to their logarithms from which a regression curve was established. Since only seven species (see Table 2) were involved in the study of muscle volumes, it was not possible to establish regression curves for the three groups defined above. Instead, a regression curve was established for all seven species, irrespective of the shape of the flight membranes. Among the seven species of bats studied, the relationship between the volume of the ventral thoracic flight musculature and the volume of the entire body, as shown by a regression curve, is 1.04. Considering the small sample size and the indiscrimination relative to the shape of the flight membrane, this ratio of 1.04 is very close to the ideal ratio of 1.16. To me, this indicates that the volume of the entire ventral thoracic flight musculature plays only a small role, if any, in the development of a particular mode of flight. That is to say, the volume of the entire ventral thoracic flight musculature increases as the volume of the entire body according to the laws of mathematics and not according to the mode of flight or phylogenetic position.

Ratio of individual flight muscles to total flight musculature.—A study of the ratios of the volume of individual ventral thoracic flight muscles to the volume of the entire ventral thoracic flight musculature in different bats was made in an attempt to investigate the possibility of variations in volumetric proportions of individual muscles from one species to another and to aid in explaining any existing variations in flight patterns. Since the sizes of the small muscles are subject to some individual variation, I recognize that usefulness of these data may be limited. At any rate, upon examination of the data in Table 2 it seems evident that the sum of the volumes of the pectoralis major and the serratus magnus (inferior) forms a constant percentage of the

ventral flight musculature. However, in those species having a relatively large pectoralis major, there seems to be a relatively small serratus magnus (inferior) and, in those species having a relatively small pectoralis major, there seems to be a relatively large serratus magnus (inferior). When one considers the action of these two muscles, as proposed by Vaughan (1959: 72, 86–87) and others, this relationship becomes most interesting. It is well known that the pectoralis major is the chief muscle involved in the downstroke of flight. The serratus magnus (inferior), with its origin on the distal surfaces of ribs one to eight and its insertion on the axillary border of the scapula, aids directly in the downstroke and may arrest the upstroke and initiate the downstroke, thus relieving the pectoralis major of much work. Since these two muscles, no doubt, play the major role in the downstroke, it appears that approximately the same volumetric proportion of the flight muscles is appropriated to the downstroke in all seven species studied.

Vaughan (1959: 88) postulates that the flexor action of the pectoralis quartus on the humerus is of much importance in quadrupedal locomotion, but of little importance in flight. If this is so, my data indicate that locomotive competence on the ground, for the species studied, is greatest in *Molossus nigricans* and least in *Choeronycteris mexicana*. Since there is not much information in the literature on the quadrupedal locomotion of bats, this inference must be substantiated by further observations. However, *Desmodus rotundus*, which is well known for its locomotive competence on the ground, has a pectoralis quartus almost as large as that of *Molossus nigricans*.

TABLE 2.—*Volumes of ventral thoracic flight musculature in seven species of bats*

Group	Species	M.S.U. No.	Volume of entire ventral thoracic flight musculature, ml	Volume of individual ventral thoracic flight muscles in ml, followed by the volumetric proportions of the individual muscles to the entire ventral thoracic flight musculature					
				Pectoralis major	Pectoralis quartus	Serratus magnus (inferior)	Serratus magnus (superior)	Serratus anticus	Subclavius
I	*Myotis velifer*	2913	.49	.35–	.01–	.1–	.02–	*	.01–
				.714	.0204	.204	.0408		.0204
	Myotis thysanodes	2892	.43	.30–	.01–	.1–	.01–	*	.01–
				.698	.0233	.233	.0233		.0233
	Choeronycteris mexicana	2886	.87	.59–	.01–	.2–	.05–	*	.02–
				.678	.0115	.230	.0575		.0230
II	*Leptonycteris nivalis*	3067	1.84	1.30–	.03–	.4–	.06–	.01–	.04–
				.707	.0163	.217	.0326	.005	.0217
	Desmodus rotundus	3610	2.32	1.50–	.06–	.6–	.10–	.01–	.05–
				.647	.0259	.259	.0430	.004	.0216
III	*Molossus nigricans*	3028	1.66	1.20–	.05–	.35–	.05–	*	.01–
				.723	.0300	.211	.0301		.0060
	Tadarida brasiliensis	3200	.59	.45–	.01–	.1–	.02–	†	.01–
				.763	.0170	.170	.0339		.0169

* The volume of the muscle was less than .01 ml and therefore not measurable with my equipment.
† Serratus anticus was not found in *Tadarida brasiliensis*.

The serratus magnus (superior) may aid in the initiation of the upstroke, according to Vaughan (1959: 71). A more thorough study including the volumetric proportions of back muscles involved in the upstroke appears to be necessary before much can be inferred from my data on the volumetric proportions of the serratus magnus (superior). A possible explanation for the rather high volumetric proportion of this muscle in *Choeronycteris mexicana* may be that, owing to the erratic, fluttery and hovering or near-stationary flight postulated for this species, a large serratus magnus (superior) is needed for the powerful upstroke. Since the serratus anticus was not measurable in most of the specimens, it will not be discussed.

The subclavius exerts a posteriad and ventrad force on the clavicle and thus counteracts the forces tending to pull the distal ends of the clavicle together and anteriad (Vaughan, 1959: 85). From my data it appears that those species with the lower aspect ratios have larger subclavius muscles than those species with higher aspect ratios. Under certain conditions when the rate of wing beat is increased, as when hovering, those species of lower aspect ratios may have a definite need for a greater subclavius muscle, whereas those species of high aspect ratio, which probably never exhibit this hovering type of flight, have no need for a relatively large subclavius.

Conclusions.—The following inferences are made from my data. The shape of the flight membrane seems to be the greatest single factor studied in determining the mode of flight. Among the dozen species of bats studied, at least three groups based on the aspect ratio (shape of the flight membrane), irrespective of phylogenetic position, can be established. Those bats with a lower aspect ratio have shorter and wider wings and have slower and more maneuverable flight than those bats with a higher aspect ratio which have longer and narrower wings and have more rapid and less maneuverable flight. The observed flight patterns of the species within each group can be judged to be approximately the same as based on field studies by other workers. The surface areas of flight membranes, within groups having similarly shaped flight membranes, increase approximately .66 times as the total volume of the body increases once. The surface area of the flight membrane per volume of the entire body is greater in those species with a lower aspect ratio than in those species with a higher aspect ratio. The total volume of all the ventral thoracic flight muscles increases approximately 1.16 times as the total body volume increases once, irrespective of the shape of the flight membrane. The sum of the volumetric proportions of the pectoralis major and serratus magnus (inferior) remains approximately constant in all seven of the species whose ventral thoracic flight musculature was studied. The volumetric proportion of pectoralis quartus may vary directly with the species' competence in quadrupedal locomotion. The exceedingly large volumetric proportion of the serratus magnus (superior) in *Choeronycteris mexicana* may be due to this bat's exceptional ability to hover. The small serratus anticus probably plays a minor

role, if any, in flight. The subclavius appears to be large in those species of lower aspect ratio, possibly in relation to the hovering flight of these species.

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LABORATORY INSTRUMENTS FOR MEASURING THE BEHAVIOR OF SHY OR NOCTURNAL SMALL MAMMALS

By LEE R. DICE

ABSTRACT: Described are runways, remotely controlled gates, recording treadles, locking relay circuits, interval timers, and electrically operated counters and timers which are useful in the construction of experimental equipment for measuring accurately many features of the behavior of shy or nocturnal small mammals.

Many small mammals are disturbed by the presence of a human being and they may not behave naturally when under direct observation. This is true for some members of domesticated strains as well as for wild individuals. Even a concealed observer may be detected by his breathing, slight movements, or odor. Also, some of those mammals which mostly are nocturnal, such as *Peromyscus*, may not react normally when the light intensity is high enough for the human eye to follow their movements. Furthermore, a shy individual may take a long time to perform a prescribed task, so that an inordinate amount of effort may be required to observe its responses directly. For these reasons, accurate measurements of the behavioral responses of many kinds of mammals require the use of automatic recording equipment.

The essential features of the automatic controlling and recording systems which I have employed in some extensive laboratory studies of *Peromyscus* behavior include runways, remotely operated starting gates, treadles that operate switches, circuits that electrially lock relays, interval timers, and recording counters and timers. This paper describes these special items of experimental equipment. Later papers will describe and discuss the measures of behavior which were obtained.

Runways.—Runways are required to control the passage of the experimental animal from one part of the apparatus to another part, for the construction of mazes and similar testing devices, and for other purposes.

Runways for *Peromyscus* may be from 2½ to 3 inches wide inside and about 3½ inches high. The sides and bottom of the runway can be made by twice folding at a right angle a sheet of tin or galvanized metal of the desired width and length. Small transverse wooden blocks positioned inside the runway, flush with its top and attached to its sides by nails or screws, give rigidity to its upper edges. The top of the runway may be covered by wire screen with a mesh of ¼ or ⅛ inch. This screen is fastened by screws to the transverse wooden blocks. The screen cover provides ventilation and illumination to the runway and also permits the observer to locate an experimental animal which may have stopped somewhere in the apparatus. The screen cover may be unscrewed when the runway is to be cleaned.

Starting gate.—In order to measure precisely the time required by an animal to perform a prescribed task, a starting gate is needed which will release him from the starting chamber at an exactly determined moment.

Such a gate may be made from a flat piece of heavy sheet metal (Fig. 1). A small hole in the piece of metal fits over a pin, on which the gate freely swings sideways. An arm extends upward above this pivot and permits the gate to be closed manually. The lower part of the gate consists of a segment of circle having a radius of about 6 inches, measured from the pivot. Near the outside edge of this lower part of the gate is a hole large enough to pass

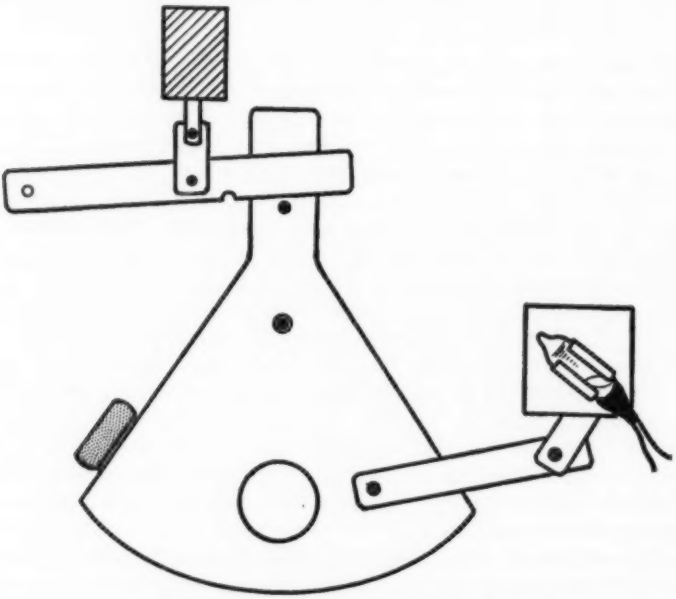

FIG. 1.—Starting gate in open position.

an animal of the size being used in the experiments. For *Peromyscus*, a hole 1⅜ inches in diameter is amply large. When the gate is hanging free, this hole coincides with the opening from the starting chamber into the apparatus and the gate is open. When the gate is swung to one side, the opening into the apparatus is covered and the gate is closed. A metal catch or trigger holds the gate in closed position. When a solenoid attached to this trigger is activated by an electric circuit, the trigger releases the gate, which then swings into open position. A rubber stop prevents the gate from swinging too far and then oscillating back and forth.

A pilot light on the instrument control panel indicates that the gate has opened. A hole in a short metal bar fits loosely over a pin attached near one edge of the gate (Fig. 1). The other end of this bar fits between the lower ends of a pair of rocker arms and is loosely connected to them by a pin. On their upper ends these rocker arms are firmly connected to an axle which carries a clip (Fig. 2) to receive a mercury switch. The length of the rocker arms between bearings should be about equal to the distance traversed by the pin on the gate when this swings from CLOSED to OPEN position. This will give about a 60° turn to the axle carrying the switch. When the gate swings to the OPEN position, the mercury in the switch closes the circuit and the pilot lights.

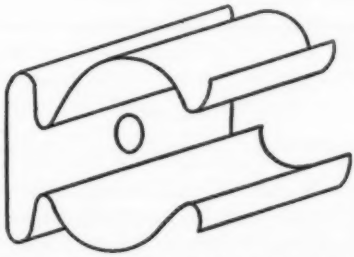

FIG. 2.—Detail of clip to hold a mercury switch.

Recording treadle.—The treadle is an efficient device for indicating the passage of an animal subject through a particular part of an experimental apparatus. A mercury switch, attached to the axle of the treadle, can be set to make or to break a circuit which controls a timer, counter, or other electrically operated instrument, either directly or through a relay. Treadles are simple and inexpensive to construct, are adaptable to many types of experimental situations, and are highly reliable in operation.

Treadles can be made of various widths and lengths to fit particular situations. I have built them as much as 12 inches wide, but this requires very light-weight material and careful balancing, if they are to be operated by an animal as small as a mouse. Mostly the treadles will be of a width to fit within runways which are between 2 and 3 inches wide. The treadle length may vary between 5 and 7 inches, depending upon the space available. Tin,

light-weight galvanized metal, or aluminum is satisfactory material. If smooth tin or aluminum is used, the upper face of the treadle should be roughened slightly to provide a non-skid surface.

The treadle platform may be cut according to the design illustrated in Fig. 3. The sides are then folded down along the dotted lines. Holes to receive the axle are next bored on each side of the treadle exactly in the middle, lengthwise, and just far enough down from its upper surface to permit the insertion above the axle of the strip of metal which forms the clamp.

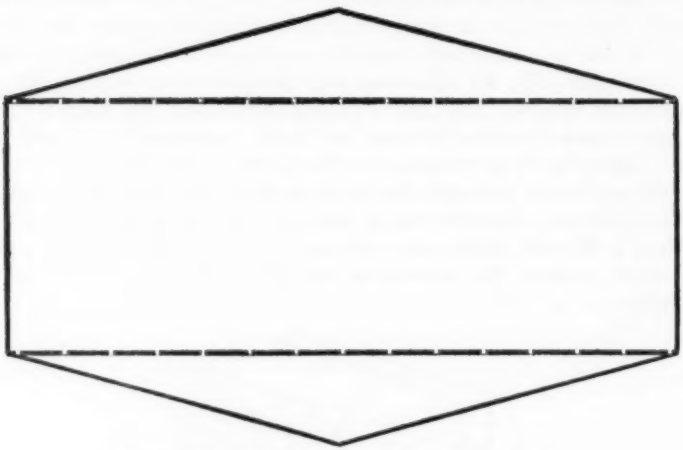

FIG. 3.—Pattern for treadle platform, before folding.

The axle for the treadle may be made from brass or steel rod having a diameter of about 5/64 inch. One or both ends of the axle should be threaded to attach the clip for a mercury switch or to hold other attachments. The axle is locked to the treadle platform by a clamp which is closed by a machine screw operated by a screw driver from above the treadle. This clamp consists of a strip of sheet metal, of which one end is fastened underneath the treadle platform by a short machine screw and the other end is loosely wrapped around the axle. Holes in the clamp allow the passage to one side of the axle of the clamping screw. A lock washer below the clamp prevents the nut on this screw from turning. The axle should be roughened slightly to afford a good grip for the clamp.

Holes are bored in the sides of the metal runway to serve as bearings for the treadle axle. If these holes are located about ¾ inch above the floor of the runway, the ends of the treadle will have more than 1 inch of up-and-down travel. This usually will be adequate to insure dependable operation of the mercury switch. The holes must be exactly opposite one another on the sides of the runway and both must be precisely the same distance above the floor. One or more washers should be placed on the axle on each side

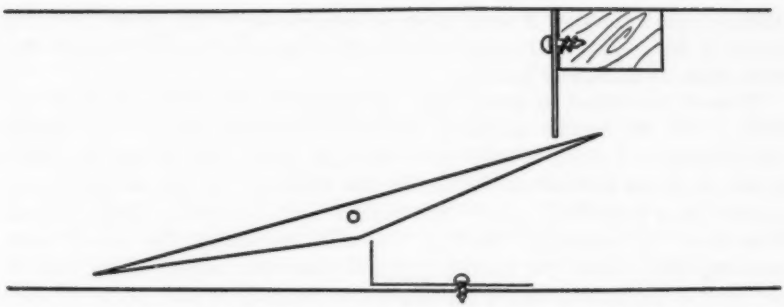

FIG. 4.—Section of two-way treadle, showing position of barrier.

of the treadle platform, to prevent this from scraping the sides of the runway.

That end of the treadle which the experimental animal will approach in the runway should usually be down, so that he can pass over readily. The treadle should, therefore, be slightly out of balance. For *Peromyscus*, which weigh from 12 to 25 grams, an unbalance that requires the addition of about 5 grams to the high end of the treadle to depress this to the floor will usually give satisfactory operation. A balancing weight, if needed, may be provided by a small machine screw fastened to the treadle platform about ⅛ of its length from one end. In mounting the mercury switch, care should be taken that its weight and that of its two flexible leads do not disturb the balance of the treadle. It is best to connect these leads to a pair of binding posts mounted outside the runway above and fairly close to the middle line of the treadle.

A mouse may sometimes pass over a treadle so fast that the relay or recording device fails to operate. Sometimes, indeed, if there is space to do so, a *Peromyscus* may jump completely over a treadle without touching it. To insure that each passage of the animal will be recorded, a barrier should be placed above one end of the treadle in such position that the treadle must be depressed completely to provide an opening sufficiently large for the

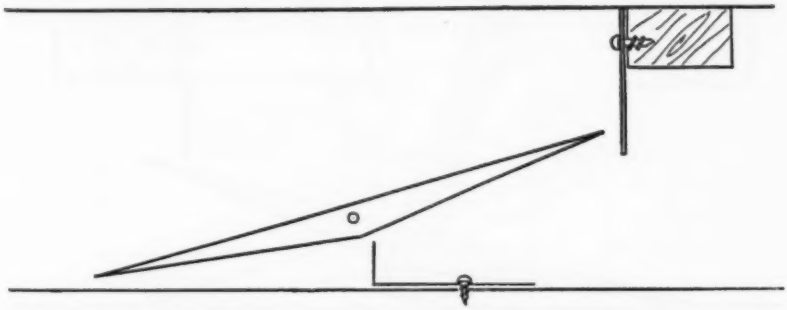

FIG. 5.—Section of one-way treadle, showing position of barrier.

animal to pass through. A small piece of sheet metal or wire screen the same width as the runway and mounted vertically above the treadle near its high end makes a satisfactory barrier.

When it is desired to permit the experimental animal to pass back and forth across the treadle in either direction, the lower edge of the barrier should be placed about ⅛ inch *above* the high end of the treadle and about ½ inch from this end *toward* the treadle axle (Fig. 4). Nearly all *Peromyscus* quickly learn to pull the end of the treadle down when they desire to pass through in the backward direction. In order to prevent the animal from crawling back, under the treadle, a metal transverse barrier is fastened to the floor of the runway below the treadle and slightly to one side of its axle.

To limit the travel of the animal to one direction only, the barrier is mounted just far enough *beyond* the high end of the treadle to afford clearance and with its lower edge extending down ¼ inch *below* the treadle end (Fig. 5). With such a one-way construction, a *Peromyscus* almost never will learn how to pull the treadle down from behind and consequently he cannot return across the treadle once he has passed through.

A treadle also may be arranged to remain in the position assumed when the mouse last passed over it. This can be accomplished by attaching a metal arm vertically to one end of the axle and fastening a small weight to the upper end of this arm (Fig. 6). A barrier should be installed above each end of the treadle. Such a two-position treadle is needed where the mouse must return over his path, as from a blind alley in a maze, or when it is desired to keep a continuous record of his position in an experimental situation where he is permitted to run back and forth over a prescribed path.

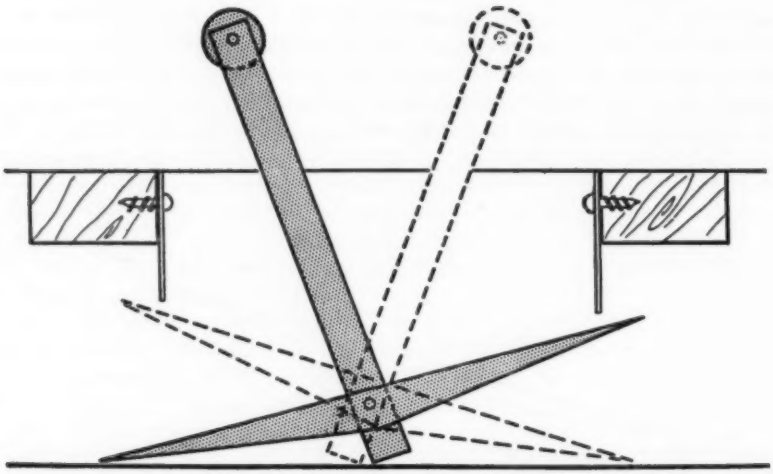

FIG. 6.—Section of two-position treadle, with weighted arm and two barriers.

Special electrical circuits.—A circuit (Fig. 7) that electrically locks a relay in closed position may be used to control timers, counters, signal lights, or other experimental equipment. The starting switch that locks the relay may be a button pressed by the operator, a switch on an interval timer, or a switch connected to a particular treadle in the apparaus. When this starting switch is closed momentarily, the relay locks in the DOWN position and remains locked until its circuit is broken either by a switch on another treadle, by an interval timer, or by the operator at the conclusion of the test.

A series of such relays can be used to measure simultaneously a number of features of behavior. Thus, one relay may control a time clock which measures the time from opening a gate until the animal crosses the first treadle in a runway. A second relay and time clock may measure the time to the second treadle, and so on. Other relays may control counters which record the number of times particular treadles are crosesd before the completion of a given task or during the period controlled by an interval timer.

Signal lamps can be inserted in the relay circuits to indicate that a particular relay is either open or is locked down and that consequently the animal subject has completed any part or all his prescribed task.

Interval timers.—Various types of interval timers, such as those used in manufacturing, can be adapted to control recording circuits, open a gate at a specified instant, vary light intensity in a prescribed sequence, or control the time of onset or duration of a stimulus. The simplest type of interval timer is one that controls a single circuit, either turning on or shutting off the current when the preset time has elapsed. Types are available also with gang switches which can control up to ten or more circuits simultaneously. One of these gangs can be wired to shut off the timer itself at the completion of its cycle, so that the sequence of operations will not be repeated until the operator again closes the circuit.

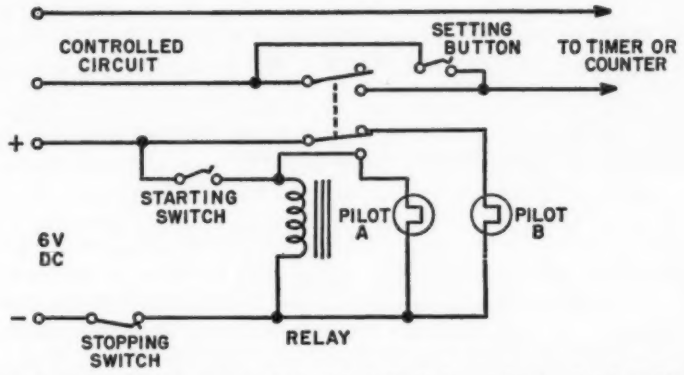

FIG. 7.—Diagram of a circuit which electrically locks a relay in closed position.

Counters and timers.—The movements of an animal subject in an experimental apparatus can best be recorded by electrically operated counters and timers. Kymographs or other types of recorders which employ paper rolls require the translation of the paper tracings into counts of treadle crossings or measures of elapsed time. The direct recording of the desired measurements will usually be simpler and more accurate.

Numerous types of electrically operated counters are commercially available. The type with mechanical reset to zero is most efficient, though the non-reset type is cheaper.

The best type of recording timer is one of laboratory type, measuring elapsed time in seconds or fractions of seconds, and provided with a manual or electrical reset to zero. A much cheaper timer consists of an ordinary kitchen clock driven by a synchronous motor. Before purchasing such a clock, however, it should be checked to make sure that the sweep second hand does not coast for a second or more after the current is shut off. Also, care should be taken to secure a clock whose dial actually is marked in seconds. Not all clock dials are so marked. A shorting button inserted in the relay circuit to the clock enables the second hand to be reset to zero or to some multiple of 10 seconds. The setting of the hands is recorded at the start and also at the close of each test and the number of elapsed seconds obtained by subtraction. This type of clock requires more effort to secure time records than does a laboratory type of timer and also there is more danger of making errors in the readings. The kitchen clock, however, does have the advantage that it will record intervals up to as much as 12 hours in length. Sometimes, therefore, I have included both a laboratory timer and a kitchen clock in the same circuit to make those measurements that might take a long time to complete.

ACKNOWLEDGMENTS

The construction of the instruments here described was financed by the Laboratory of Vertebrate Biology and Faculty Research Fund (Project 923) of the University of Michigan and by grants from the National Institute of Mental Health to the University of Michigan (M-375) and to Cranbrook Institute of Science (M-1650 and M-2050). Hal F. Schulte, Jr., gave advice about the relay circuit.

Dept. of Zoology, Univ. of Michigan, Ann Arbor, and Cranbrook Institute of Science, Bloomfield Hills, Michigan. *Received 12 September 1960.*

COPULATION AND GESTATION IN THE POCKET GOPHER

By Peter Schramm

Abstract: Two separate breedings were observed in the pocket gopher, *Thomomys bottae*, of the San Francisco Bay region of California. Copulatory behavior is described in detail and is a relatively lengthy procedure involving numerous periods of intromission. Gestation periods were nearly 19 days in two instances. Both females showed external and histologic evidence of heat at the time of copulation. One parturition was observed. Labor movements consisted of a swelling and forward bulging of the dorso-lateral walls of the abdomen. The female did not assist the delivery except by these movements.

In the course of a study of reproduction in the pocket gopher, *Thomomys bottae*, in the San Francisco Bay region of California, two separate breedings in captivity were observed. Neither the length of gestation nor details of copulation has been recorded in the literature on this fossorial mammal, hence they are reported here along with a brief description of one observed birth. The reproductive study was initiated in the fall of 1958 and is still in progress.

Methods.—Animals were taken from the field in the early part of the breeding season and caged individually in 5-gallon cans in which one end was removed and replaced by a lid of ¼-inch wire mesh. Wood shavings served as litter and an abundance of potatoes, lettuce and other greens was furnished at all times. Such succulent food provided ample water. Vaginal smears were taken, laparotomies performed, and estrus and associated ovarian changes were observed and recorded.

Females representing all stages of reproductive development, including pregnant females, were placed periodically with males in breeding condition as indicated by scrotal enlargement. Since all kill-trapped males in similar condition were found to have mature sperm in the cauda epididymis, it is assumed that these living males were also in breeding condition. It should be mentioned, however, that Gunther (1956), who studied a continuously breeding population of *Thomomys bottae* in irrigated alfalfa fields near Davis, California, stated that the actual breeding state of male pocket gophers could not be predicted from external appearance, palpation or manipulation of the scrotal region. He found individual differences in cyclic presence or absence of epididymal sperm. It may be that pocket gophers from irrigated lands are less regular in the breeding cycle than those from non-irrigated land.

A glass terrarium of 10×16 inches with 1 inch of fresh, moist soil was used as a neutral breeding cage. Animals were placed together for periods from 5 to 60 minutes and kept under constant observation during this time.

Of 80 breeding trials, 55 involved females that appeared to be in or close to estrus, as diagnosed by a swollen vulva, open vagina, and the presence of large numbers of cornified cells in the vaginal smear. The two successful breedings involved females that were in such an estrous condition.

Copulation.—The sequence of repeated copulatory acts is a lengthy procedure in the pocket gopher. The two instances observed will be described separately, as they varied in certain details.

In one breeding the male and female ignored each other for the first 5 minutes in the breeding cage. They explored the cage and pushed dirt around, occasionally bumping into each other. During these brief contacts a soft, guttural purr was heard which seemed to come from the female. Once the male mounted the female from the front and attempted several weak pelvic thrusts. At the end of 5 minutes in the cage the male suddenly displayed great interest in the female and attempted to mount her. She promptly turned her hind quarters to him, and intromission was achieved. Pelvic thrusts were made beneath and from one side of the base of the female's tail, and were very rapid at first, slowing to a stop at the end of 10 to 20 seconds. The male would then withdraw and switch over to the other side of the female's tail, achieve intromission and resume the rapid thrusts. During these thrusts he repeatedly lunged forward, clutching at the fur on the female's neck and shoulders with his front paws. He would slip back repeatedly only to lunge forward again to regain his grasp. At the end of an intromission period, as the male slowed to a stop, he was sometimes on his side and at other times on top of the female. He invariably switched to the opposite side of the female's tail between intromission periods. Twenty periods occurred in rapid succession in 8 minutes. They averaged 15 seconds but several longer periods of 30 seconds were observed.

After this first copulatory period the two gophers resumed exploring the cage and pushing dirt around. The purring noise was heard again during accidental contacts.

Eleven minutes later the male, after a feeble attempt to mount from the front, achieved another successful 20-second intromission after which he lay on the female quietly for 1 minute. Cage exploring was resumed, and 4 minutes later the male achieved 5 more intromission periods in quick succession, averaging 15 seconds each. Twenty-five minutes after this third copulatory period, three more intromissions followed one another in rapid succession.

During all these copulation periods the female was completely docile and receptive. She remained in an upright position with eyes closed.

One minute after the last copulatory period the male returned to the female, flipped her over on her back and attacked her with his incisors. The two were separated immediately.

The second observed copulation differed somewhat from the first. The male showed sexual interest immediately upon meeting the female in the cage. She was not as receptive as the other female described. The male had to chase and catch her several times before he was successful in mounting and achieving intromission. The female was small, weighing only 80 grams, while the male weighed over 200 grams; hence he had little trouble in holding and mounting her.

Intromission was achieved six different times in a 25-minute period. The first intromission lasted 4 minutes with no separation or switching to opposite

sides of the tail. The thrusts were rapid and then slowed to a stop at 15-second intervals much as in the first case described. The other five copulations lasted approximately 1 minute each and were more or less evenly spaced throughout the 25-minute period.

The female gave several high-pitched squeaks during copulation but became more docile and receptive as it progressed. The guttural purr was not heard. The male did not attack the female at the end of copulation but simply lost interest in her.

In addition to the two copulations described, one fairly vigorous but unsuccessful attempt and ten momentary and very feeble attempts were observed. Eight of these, including the vigorous attempt, involved the male that took part in the first successful breeding. Most of his attempts involved females in estrus but two involved non-estrus females. These observations seem to indicate that certain males have more copulatory drive than others and that such males are as necessary for successful breeding as females in heat.

Fighting of captive pocket gophers placed together has been commonly reported in the literature (Tryon, 1947; Howard and Childs, 1959). The larger and heavier animal, usually a male, kills the smaller animal (Howard and Childs, *op. cit.*). A notable exception was recorded by English (1932) who reported pairs of captive *Geomys breviceps* living together peacefully in the same nest.

Fighting in these numerous breeding trials was almost non-existent. The attack at the conclusion of the first breeding described is a notable exception. The few other fights observed were initiated by males with particularly aggressive dispositions.

There might have been more fighting if animals had not been placed in neutral cages or had been left together for longer periods. However, its absence is probably also due to the fact that all animals used were in some stage of breeding condition. Breeding in the pocket gopher is presumably associated with a decrease in territorial behavior (Howard and Childs, *op. cit.*; Hanson and Miller, 1959).

Gestation.—In one breeding, parturition began approximately 18 days and 18 hours after copulation and was completed 4 hours later. The size of this litter was 4. This female had been in captivity for 10 days before showing external and histologic evidence of estrus. The copulation occurred during this estrus. In the other breeding, a single young was born 18 days and 23 hours after copulation. This female was in estrus and copulated with a captive male the same day she was captured. Both females were assumed to be non-pregnant when captured, since estrus and thorough copulations were observed.

The newborn gophers of both litters appeared to be as large and fully developed as young born in captivity to females that were pregnant when brought in from the field. Newborn gophers of this species weigh 2 to 3 grams and are extremely altricial, being almost hairless, blind and helpless (Hill, 1934).

The gestation period of *T. bottae* has been estimated by Scheffer (1938) to be one lunar month. He arrived at this figure after numerous field observations on several species of gophers. Several workers have used Scheffer's estimate of gestation to calculate brood indices (Miller, 1946; Wood, 1949; Wing, 1960).

Parturition.—Some details of parturition were observed in the birth of the single young. The actual delivery was not observed because nest material obscured the view. Labor movements were observed for half an hour. The dorso-lateral walls of the female's abdomen would swell and bulge forward; at the same time her whole body would move forward slightly. These movements were frequent at first, occurring once every minute, but gradually became less frequent until they finally ceased. Shortly thereafter a newborn animal was detected under the female. She did not assist the birth in any way other than by these labor movements.

Parturition has been described for *Geomys pinetis* (Barrington, 1942) and differs somewhat from that observed for this species. In *Geomys*, the female spread her hind legs and arched her tail during the delivery. In addition, sharp squeaks, presumably of pain, accompanied early labor. The forward bulging of the abdomen was not observed.

ACKNOWLEDGMENTS

Thanks are due to Drs. Seth B. Benson, Oliver P. Pearson and Alden H. Miller for critically reading the manuscript.

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Museum of Vertebrate Zoology, Univ. of California, Berkeley 4. *Received 13 June 1960.*

VERTEBRATES INHABITING POCKET GOPHER BURROWS IN COLORADO

By Terry A. Vaughan

Abstract: Twenty-two species of vertebrates have been recorded in Colorado as using pocket gopher burrows for retreats and foraging routes, and the local occurrence of several reptiles and of the tiger salamander is determined by the presence of these burrows. Adult tiger salamanders often live in burrows occupied by pocket gophers; apparently these two animals are mutually tolerant. Ground squirrels are pocket gophers' strongest competitors for burrow systems and occasionally force pocket gophers from their burrows. The plugging by pocket gophers of open entrances to their burrows is important in excluding other burrow-inhabiting vetebrates as well as predators.

In many parts of the western United States the workings of pocket gophers are conspicuous features of the terrain. The extensive burrow systems dug by these animals, and the large quantities of soil they push to the surface of the ground, have a marked effect on the biota. Many species of vertebrates are at least partially dependent upon pocket gopher burrows for places of refuge and for foraging routes, and some weakly fossorial species seem to prefer to dig retreats in the loose soil of pocket gopher mounds rather than in more compact soil. The following observations were made in the summers of 1955 to 1960 in Colorado, and indicate some of the vertebrates dwelling in pocket gopher burrows. The species involved are the valley pocket gopher, *Thomomys bottae*, the northern pocket gopher, *T. talpoides*, and the plains pocket gopher, *Geomys bursarius*. My sincere thanks are extended to Richard M. Hansen who made available many observations concerning the burrows of *T. talpoides*.

Ambystoma tigrinum, tiger salamander.—In some areas, particularly in the parklands of the spruce-fir zones in the Rocky Mountains and in the sandhill sections of eastern Colorado, adult tiger salamanders are, next to pocket gophers, the vertebrates most commonly observed in pocket gopher burrows. From burrows of the plains pocket gopher in the sandhills 10 miles south of La Salle, Weld County, in the spring and summer of 1960, for example, the following vertebrates were taken: four tiger salamanders; two prairie rattlesnakes (*Crotalus viridis*); two gopher snakes (*Pituophis catenifer*); two Ord's kangaroo rats (*Dipodomys ordi*); and one spotted ground squirrel (*Citellus spilosoma*). At the La Salle locality, on 27 April 1960, an adult tiger salamander and an adult male *Geomys* were caught in the same trap at the same time. An adult female *Geomys* and an *Ambystoma* were taken together in the same trap on 1 July 1960, 15 miles north of Akron, Washington County. Two tiger salamanders have been taken in the burrows of *T. bottae*, one at a locality 7 miles south of Cotopaxi, Fremont County, and one at La Veta, Huerfano County.

In all areas where pocket gophers have been studied intensively in Colorado, tiger salamanders have been found in pocket gopher burrows or in the loose soil of their mounds. It is clear that *Ambystoma* inhabits burrows occupied by pocket gophers, and it appears that these two species are mutually tolerant.

The tiger salamander was the only vertebrate observed to have this relationship with pocket gophers. In certain habitats, for example in semi-arid sandhill areas, adult salamanders may habitually occupy the cool, humid burrows of pocket gophers, and salamanders perhaps owe their presence in these areas to the abundance of pocket gophers. Salamanders probably enter the burrows by digging into mounds. On Grand Mesa, Mesa County, in July 1960, an adult *Ambystoma* was observed burrowing into a freshly plugged pocket gopher burrow.

Scaphiopus sp., spadefoot toad.—In the sandhills 10 miles southeast of La Salle, Weld County, a spadefoot toad was found on 18 May 1960, 12 inches below the surface of the ground in the soil used by a *Geomys* to plug its burrow.

Terrapene ornata, ornate box turtle.—The box turtle commonly seeks refuge in the abandoned burrows of *Geomys* in sandhill areas. In May 1960, short burrows made by box turtles were frequently found in pocket gopher mounds.

Cnemidophorus sexlineatus, six-lined racerunner.—In eastern Colorado sandhills areas, partially caved-in sections of abandoned pocket gopher burrows seem to be the preferred retreats for racerunners.

Holbrookia maculata,, earless lizard.—Pocket gopher burrows are occasionally used as hiding places by this species, but it prefers smaller burrows such as those of pocket mice.

Pituophis catenifer, gopher snake.—When pursued, gopher snakes repeatedly escaped capture by entering abandoned pocket gopher burrows, and they probably rely on these refuges as winter quarters. Two gopher snakes were caught in gopher traps in eastern Colorado, and two were disturbed in the act of swallowing trapped pocket gophers.

Crotalus viridis, prairie rattlesnake.—In the sandhill sections of eastern Colorado, where little other shelter is available for snakes, the primary retreat for rattlesnakes seems to be pocket gopher burrows. In the summers of 1959 and 1960, five rattlesnakes were observed in areas with sandy soil: one was caught in a trap set in a burrow occupied by a *Geomys*; one was dug from a burrow occupied by a pocket gopher; two escaped down unoccupied pocket gopher burrows; and one, when first seen, was coiled on a gopher mound next to an open, unoccupied burrow.

Scalopus aquaticus, eastern mole.—The small burrows of the eastern mole have on occasion been found to intersect the burrows of *Geomys* at a sandhill locality 15 miles north of Akron, Washington County, and near the Cimarron River, 16 miles south of Stonington, Baca County. In Colorado, moles may use parts of pocket gopher burrows as foraging runways. Two moles were trapped in shallow runs that intersected pocket gopher burrows. In October 1958, of 32 *Geomys* trapped at the Akron locality, approximately 10 were partially eaten while in the trap. In each of these cases a mole run was found opening into the pocket gopher burrow.

Sylvilagus auduboni, desert cottontail.—In eastern Colorado this species regularly seeks refuge in enlarged sections of abandoned pocket gopher burrows, especially where the burrows open into banks.

Citellus sp., ground squirrels.—In most areas in Colorado where pocket gophers have been studied, the strongest competitors for the gopher's burrow systems seem to be the smaller ground squirrels. In June 1957, at Parvin Lake, Larimer County, Richardson's ground squirrels (*Citellus richardsoni*) occupied the burrows of *T. talpoides* shortly after the original occupants were trapped. The impression was gained that the ground squirrels were holding these burrows against reinvading gophers. Aldous and Ellison (Ecology, 33: 177–186, 1952) reported similar competition between *C. armatus* and *T. talpoides* in Utah. In eastern Colorado, thirteen-lined ground squirrels (*C. tridecemlineatus*) were trapped in the burrows of *T. talpoides* and *Geomys*. Spotted ground squirrels were observed entering *Geomys* burrows soon after they were opened, but the large and pugnacious plains pocket gophers are probably able to drive the squirrels from their burrows. Golden-mantled ground squirrels (*C. lateralis*) have been observed repeatedly to occupy pocket gopher burrow systems from which the original occupants were temporarily removed. Observations made in the summer of 1959, while live-trapping, banding and releasing *T. bottae* and *T. talpoides* in parts of Fremont County where *C. lateralis* was common, indicated that occasionally, when burrow systems were opened in order to set traps, *C. lateralis* drove out the resident pocket gophers and occupied the burrows. The aggressive behavior of ground squirrels suggests that the habitual plugging of the entrances to their burrow systems by pocket gophers may be as important in excluding such strong competitors as ground squirrels from the burrows as in keeping out predators.

Dipodomys ordi, Ord's kangaroo rat.—Considering the abundance of kangaroo rats in sandhill areas, surprisingly few are taken in pocket gopher burrows. Trapping in the spring and early summer of 1960 in eastern Colorado, for example, yielded only two kangaroo rats together with more than 300 pocket gophers. In contrast, in machine-made burrows at a sandhill site, *Dipodomys* and *Geomys* were taken in the ratio of roughly 2 to 5. Kangaroo rats may be warned away from the occupied burrows of pocket gophers by the odor of the occupants.

Peromyscus maniculatus, deer mouse.—Abandoned pocket gopher burrows are favorite retreats of deer mice in grassland areas where rocks are scarce. Short burrows of small diameter usually lead from the larger gopher burrows to the surface of the ground.

Microtus sp., meadow voles.—Montane voles (*M. montanus*) were occasionally taken in live traps in burrows occupied by *T. talpoides* on Black Mesa, Gunnison County, in the summers of 1957 and 1958. A prairie vole (*M. ochrogaster*) was trapped in the burrow of a *T. talpoides* and another was found dead in the burrow of a *Geomys* in the summer of 1960 in eastern Colorado. The dead *Microtus* had been treated as a bit of refuse by the pocket

gopher and had been pushed into a lateral tunnel which had then been plugged.

Mustela frenata, long-tailed weasel.—In a pocket gopher trapping project in Nevada, J. R. Alcorn took 22 long-tailed weasels along with 14,695 *T. bottae* (Hall, MAMMALS OF NEVADA, Univ. Calif. Press, 1946). Trapping for pocket gophers on Grand Mesa, Mesa County, Colorado, in the summer of 1955, when pocket gopher populations were high, yielded weasels at the rate of approximately one weasel for every 35 *T. talpoides*. In the summer of 1957, when pocket gopher numbers were low as compared to 1955, only approximately one weasel per 300 pocket gophers was taken, and in the summer of 1960, when pocket gophers were moderately abundant, about one weasel per 120 pocket gophers was taken. On many occasions weasels were observed using pocket gopher burrows as retreats and foraging routes, and abandoned burrows as sites for raising young. On two occasions, on the plains of eastern Colorado, long-tailed weasels were trapped in the burrows of *Geomys*.

Other vertebrates known to inhabit pocket gopher burrows in Colorado are: *Bufo cognatus*, plains toad; *Speotyto cunicularia*, burrowing owl; *Onychomys leucogaster*, northern grasshopper mouse; and *Mephitis mephitis*, striped skunk.

The importance of pocket gopher workings to terrestrial vertebrates at one locality in Colorado can be illustrated by comparing the total number of species occurring in the area to the number of species which commonly utilize pocket gopher burrows for shelter or for foraging routes. At a 110-acre study area in the sandhills, 10 miles southeast of La Salle, Weld County, 22 species of terrestrial vertebrates have been recorded; 15 of these, or 68 per cent of the species, regularly inhabit the occupied or abandoned burrows of pocket gophers.

Experiment Station, Colorado State Univ., Fort Collins. *Received 15 August 1960.*

[Technical Journal Article S.S. 688, Colorado Agricultural Experiment Station.]

WINTER HOME RANGES OF THE RED-BACKED MOUSE AND WHITE-FOOTED MOUSE

BY JAMES R. BEER

ABSTRACT: A study of the home ranges of the white-footed mouse, *Peromyscus leucopus*, and the red-backed mouse, *Clethrionomys gapperi*, was carried out in northern Anoka County, Minnesota, during the winter and while the ground was covered with snow. Trap-revealed home ranges averaged 0.27 and 0.25 acres, respectively, when calculated by the minimum-home-range method and 200 and 217 feet, respectively, when calculated by the greatest-diameter method. The animals restricted their movements for the most part to protected areas such as brush piles and under logs rather than traveling over the whole area as they appeared to do in the summer and fall. Temperatures as low as –19°F did not prevent the animals from moving about.

Very little has been published on the winter movements and home ranges of small mammals living in regions which have extended periods of snow cover. The present report deals with the movements and home ranges of the red-backed mouse, *Clethrionomys gapperi*, and the white-footed mouse, *Peromyscus leucopus*, on the Anoka outwash sand plain in Anoka County, Minnesota. Live trapping was carried out between 18 December 1958 and 24 February 1959. During this period there was a continuous snow cover but at no time was it deep enough for the mice to tunnel under it. The boundaries of the area studied were determined by the trails and tracks of the mice. There was very little sign of small mammals in the area immediately adjacent to that shown in Fig. 1. The vegetation was composed of an overstory of mature elm (*Ulmus americana*), basswood (*Tilia americana*) and a few oaks (*Quercus* spp.) and a sparse understory of hazel (*Corylus americana*) and a few other woody plants. The herbaceous vegetation was of little value as cover except for the grasses and sedges in the adjacent wet meadows. During the period of trapping, the minimum daily temperature varied from 22° to –19°F.

Observations during previous winters, when the ground was covered with snow, indicated that both species of mice restricted their movements largely to well-defined trails and travel areas. These usually followed along or under logs, brush piles or other protective cover or, if in the open, took the shortest route between points of refuge. The red-backed mice made narrow well-packed trails while the white-footed mice used travel areas which were often up to 2 feet wide. Previous trapping also showed that the mice seldom left these travel areas to examine baited traps even though the traps were only a few inches away. This, especially with respect to the white-footed mice, is in direct contrast to the behavior patterns observed during summer and fall.

With these items of information as guides it was decided that the usual grid system of setting out traps would not yield results. Instead, traps were placed wherever sign of recent mouse activity was found. Those areas with numerous trails and places of refuge were trapped heavily; those devoid of tracks or trails were not trapped. By continuously moving the traps, the whole area was trapped over several times. The traps were usually left out for 3 to 5 days in one place but if an individual mouse was taken 2 successive days at a station, the trap was moved immediately. All trap stations at which mice were captured were located on a map to within a foot.

The trap used was a wooden holding box with the tunnel from a Longworth trap used as the capture apparatus (Fig. 2). The traps were built with a compartment in the bottom in which a hand warmer could be placed. White gasoline was used in the hand warmers since a single filling would last for over 24 hours. The heating unit was sealed off from the holding chamber by an aluminum sheet which conducted the heat readily and kept the fumes from entering the holding chamber. Above this was a hardware cloth floor to keep the mice from coming in contact with the high temperatures found

locally on the aluminum plate. It was found that both species would survive up to 24 hours in this trap without nest material until the environmental temperature dropped to below 0°F. At temperatures below this, condensation would occasionally collect and extinguish the heating unit.

It was found that if these same traps were stuffed tightly with fine marsh hay into which the mice could burrow and make a nest they would usually survive when the environmental temperatures dropped to as low as –19°F, which was the coldest temperature recorded during the study. It was also found that a food and water supply was needed if the animals were to survive. The food used was bread or an oatmeal cooky. Water was supplied by pieces

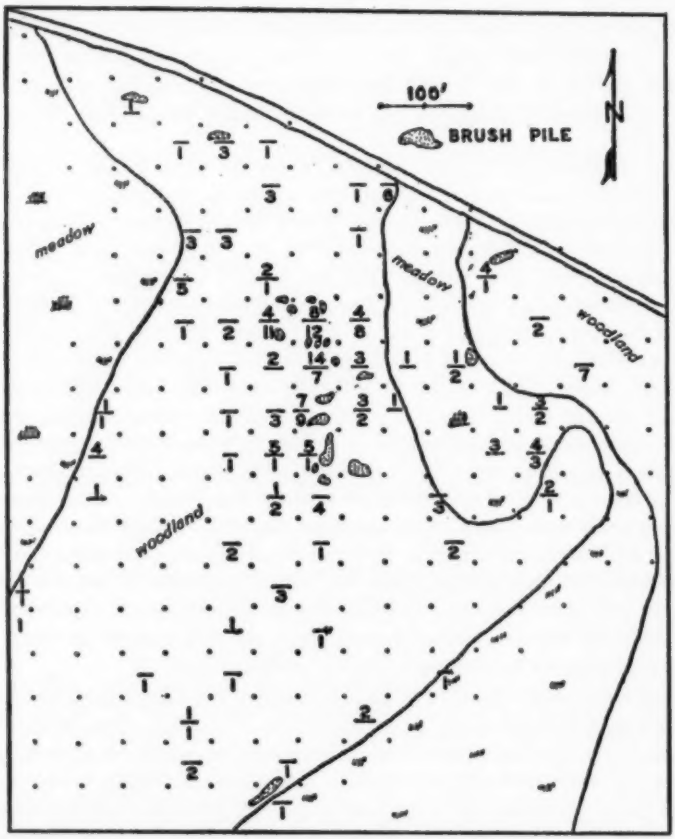


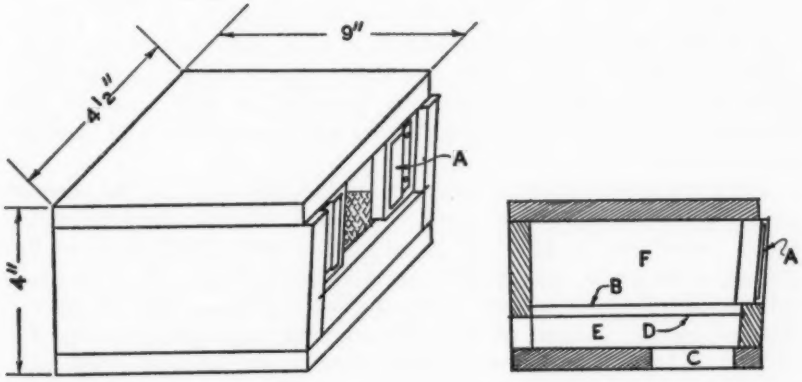
FIG. 1.—Map of study area showing the distribution of woodland and wet meadow. The number of captures of red-backed mice and white-footed mice for each 50-foot square are given as number of captures of red-backed mice over the number of white-footed mice.

of raw potato in the trap. If either food or water was missing, the animals seldom survived for even a relatively short period.

During the winter, 36 white-footed mice were captured from 1 to 13 times each for an average of 3.9 captures per animal; 28 red-backed mice were taken from 1 to 17 times each for an average of 3.3 captures per animal. A few meadow mice, *Microtus pennsylvanicus*, short-tailed shrews, *Blarina brevicauda*, and masked shrews, *Sorex cinereus*, were captured but, with the exception of one meadow mouse, these data were not suitable for analysis since the animals were either captured but once or only at a single station.

Due to the methods of obtaining the movement data and to observations of trails, it was decided that the greatest-diameter method of analysis showed best the area with which the animal was familiar and the minimum-home-range method of analysis showed best the area in which the animals concentrated their activities (Hayne, 1949).

For the 27 white-footed mice that were taken at two or more stations, the average greatest diameter was found to be 199 feet with extremes from 29 to 500 feet. Taking the data from eight animals that had been captured at five or more stations, the average greatest diameter was 200 feet with extremes from 111 to 312 feet. For the 17 red-backed mice taken at two or more stations, the average greatest diameter was 182 feet with extremes from 20 to 427 feet. Using the data from five individuals taken at five or more stations, the average greatest diameter was 217 feet with extremes from 111 to 292 feet. The single meadow mouse had a greatest home-range diameter of 321 feet. If the average greatest diameters are taken to represent the diameter of a



PICTORIAL VIEW SECTIONAL VIEW

FIG. 2.—Details of the holding box to which the Longworth door mechanism was attached. A—flange for attachment of door mechanism; B—hardware cloth floor; C—ventilation hole for heater; D—aluminum plate; E—chamber for heating unit; F—holding chamber. The box was made of ½-inch lumber.

circular home range, the average home range for the white-footed mice would cover about 0.72 acres and for the red-backed mice about 0.84 acres; that of the meadow mouse was about 1.84 acres. Based upon a knowledge of the habitat, and from study of the tracks in the snow, it would appear that these figures represent the areas with which the mice are familiar but that large segments of the area were seldom visited.

If the minimum-home-range method of connecting the outside points of capture is used, we find that, by taking the data from the 20 white-footed mice which were taken at three or more stations, the trap-revealed home ranges vary from 0.03 to 0.93 acres with an average of 0.21 acres. If only the data from those animals that were captured at five or more stations are used, the average home range is estimated to be about 0.27 acres. When using the data from the 13 red-backed mice which were captured at three or more stations, the minimum home range estimates vary from 0.02 to 0.40 acres with an average of 0.15 acres. If only those data for animals taken five or more times are used, the minimum home range estimates vary from 0.12 to 0.40 acres with an average of about 0.24 acres. The minimum trap-revealed home range of the single meadow mouse was found to be about 0.09 acres. Based on observations of tracks, trails and actual centers of activity, it appears that these minimum home range figures, with the possible exception of the single meadow mouse, are very close to the true size of the areas in which these species concentrate their activities.

The home ranges of the red-backed mice based on the greatest-diameter method of analysis are similar to the average summer home range of 0.83 acres found by Frenzel (unpublished data) for 42 animals taken from 3 to 24 times each, the 1.24 acres recorded for five individuals by Blair (1941), and the 0.70 acre average for 5 individuals found by Marshall (*in* Gunderson, 1959). Gunderson (1950) found that three animals had an average home range of 0.23 acres during the summer. However, his study area was only 210 feet wide so it is probable that the area was too small for valid estimates of home range.

The average sizes of home ranges of white-footed mice for the summer period have been reported as averaging 0.21 and 0.27 acres for females and males, respectively, in Michigan (Burt, 1940). Fitch (1958) reported the average home range size for this species as being about 0.16 acres when estimated by the minimum-home-range method; and when estimated on the basis of average distance of successive captures, 0.35 and 0.42 acres for males and females, respectively. These home range estimates agree with the size of area on which the white-footed mice in this study concentrated their activity, but are considerably smaller than the area with which they were familiar. However, it is difficult to make direct comparisons since trap spacing, location, and the types of analysis are not strictly comparable in these several studies.

Near the center of the study area there was a group of small brush piles. It was in this small area that the white-footed mice and red-backed mice centered their activities (Fig. 1). Most of the mice of both species that worked these brush piles had well-defined travelways from one brush pile to another. Only occasionally would they leave these trails and travel considerable distances to other points of refuge.

The white-footed mice had three areas about which their movements centered. The main area was the central group of brush piles. There was a minor center of activity in the southern end of the study area where oaks dominated and where there was a fairly heavy understory of hazel brush. Another small group was centered in the northeast corner of the area. In these latter two areas, the white-footed mice centered their activities about hollow trees and used the few logs present, as protection while traveling, where possible. The red-backed mice were somewhat more restricted, being found primarily in the central area where the brush piles afforded protection. A few animals were taken occasionally in the heavier cover along the edges of the wet meadows.

Neither species appeared to use the sedge and grass cover to any extent while traveling. Instead of crossing the small meadow in the study area, the mice would usually travel around it, using the brushy edges as lanes. If they were found out in the meadow, it was usually near a log or stump. For the most part both species, and especially the white-footed mice, avoided traveling through the sedge and grass in the meadows.

The winter movements appeared to be more restricted than those in the summer. The travel lanes were quite restricted whereas in the summer the travel, based on direct observation and randomly set traps, was more at random and the whole home range was utilized to a much greater extent. Many hours were spent on the area but no white-footed mice were seen during the daylight hours. However, it was not uncommon to see the red-backed mice and, in certain areas, meadow mice scurrying along the trails. Since the traps were checked but once a day, the proportion of the total movement that took place in the daytime cannot be estimated.

During the period of the study, ten (36 per cent) of the 28 red-backed mice and seven (19 per cent) of the 36 white-footed mice handled were found dead in the traps. In terms of handlings, the loss was about 10 per cent for the red-backed mice and 5 per cent for the white-footed mice. Most of this loss was due to malfunctioning of the heating unit at low temperatures and to inadequate food or water supply in the traps. However, the rate of loss for the red-backed mice was quite comparable to that found by Frenzel (unpublished data) during the summer in northern Minnesota. It is felt that, with some modifications of the heating unit and possibly a slightly larger nest box, this loss could be materially reduced.

The area was known to be in the hunting grounds of the short-tailed weasel, *Mustela erminea*, red fox, *Vulpes fulva*, and barred owl, *Strix varia*.

Some loss of the population undoubtedly resulted from their presence. The number of animals captured per unit of effort declined gradually throughout the period until about 10 February. At this time, approximately half of the mice which were on the area on 18 December were still alive and using the area. Between 11 and 15 February, only one or two mice were caught per day and from 16 to 24 February only one capture was made. It appeared that, in a period of about one week, most of the animals on the area at that time died or migrated.

A considerable area in the general region and in comparable habitat was worked throughout the period and, based on the frequency of tracks in the snow, this loss of animals was quite widespread, so the loss of individuals on the study area could not be attributed to weakening of the animals from handling. On 10 April a line of 348 stations, set 30 feet apart with three snap traps at a station, was set out through this habitat. Only six white-footed mice and one red-backed mouse were taken during the three days this line was left out. During the previous October, 350 trap stations set out in similar fashion took 155 white-footed mice and 52 red-backed mice. During the previous winter, 146 white-footed mice and 105 red-backed mice were taken from 2 to 4 November; during the following April, 300 trap stations also left out for three days took 48 white-footed mice and 32 red-backed mice. It might be postulated that this population crash was due to the fact that it was a cold winter and there was very little protection afforded by the snow and that the animals had run out of reserves with which to combat the cold. The coldest temperatures experienced did not seen to curtail the movements of either species.

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Dept. of Entomology and Economic Zoology, Univ. of Minnesota, St. Paul. *Received 16 June 1960.*

[Paper No. 4417, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.]

LIFE HISTORY OF THE PHENACOMYS VOLE

By J. Bristol Foster

Abstract: The discovery of unusually high populations of the heather vole, *Phenacomys ungava*, afforded an opportunity to study the life history of this uncommon microtine. Detailed notes are recorded for the animal's development, breeding behavior, nesting habits, habitat requirements, food preferences, enemies and behavior. Where possible, the observations have been compared to those on the closely related *Phenacomys intermedius*, with the intention of throwing light on the problem of whether the two species are conspecific. Using these non-morphological criteria, the two species do seem to be very similar.

It is pointed out that the rarity of this species in trap-line catches may be due to unsuitable trapping methods rather than to the actual scarcity of the vole.

The heather vole, *Phenacomys ungava*, or simply the phenacomys vole (Plate I), is a short-tailed, yellow-nosed, microtine rodent whose range extends from the Mackenzie River Basin through northern Manitoba and Ungava to Labrador and south almost to the American border for most of its length (Hall and Cockrum, 1953). *Phenacomys intermedius* is morphologically very similar and extends its range through the mountains of much of western North America. Crowe (1943) considers the two conspecific but as yet there appears to be insufficient study to warrant this conclusion (Foster and Peterson, 1961), and they are considered distinct in the present paper for the purpose of comparison. The long-tailed group of *Phenacomys* (*P. longicaudus*, *P. albipes*, *P. silvicola*) are clearly distinct from those above, and are confined to the extreme western United States.

Only a few years ago virtually nothing was known about *P. ungava*; it was considered to be one of the rarest of Canadian mammals. Since then high populations have been encountered in two localities: the vicinity of Authier-Nord, Abitibi-ouest County, Quebec (Royal Ontario Museum expedition, 1953), and Ft. Churchill, Manitoba (the author in 1954). Bateman (1953) and Peterson (1955) also refer to an abundance of this species.

P. intermedius, on the other hand, has always been reported more common within its range. Consequently, before the present study was initiated, considerably more was known about it than about *P. ungava*.

In this paper the two species are compared with the intention of possibly clarifying their taxonomic status by employing non-morphological criteria.

Concomitant with the present paper is that of Foster and Peterson (1961). It will be repeatedly referred to where it relates to the present paper. For a general account of the small mammals of Ft. Churchill, see Smith and Foster (1957).

DEVELOPMENT

Prior to this work, only one nest of *P. ungava* was recorded in the literature (Miller, 1897); it contained no young. In the closely related species, *P. intermedius*, Shaw (1924) and Racey (1936) each found a nest with young, four

and two respectively, but were unable to record their development. Apparently no *P. intermedius* have been kept in captivity. Hence, this phase of the mammal's life history was virtually unknown until the research at Ft. Churchill was undertaken. At this locality, 25 phenacomys' nests were discovered, but only one contained young, and it was a single, dead, two-week-old specimen. Consequently, our knowledge of the development of young phenacomys is limited to the offspring of 15 litters born in the laboratory at Ft. Churchill.

Youth.—At birth the average weight of the young of eight litters was 2.4 g (2.0–2.7), and each had a crown-rump measurement of about 3.0 cm. The young are pink, wrinkled, hairless and blind. By the end of the first day, the dorsum has become slightly pigmented blue-black, the skin is less wrinkled, and vibrissae may be clearly seen on the muzzle. On the second day, the young are capable of vocalization, the dorsum is darker, and the vibrissae are about 3 mm long. By the third day, the dorsum, including the head, tail and outer surface of the legs, is a blue-black, while the rest of

PLATE I

Phenacomys ungava and 9-day-old young.

the animal remains pink. On the fifth day the rump is usually covered with flaked skin, and is slightly pubescent. At six days the whole body appears satiny with fine fur, especially on the dark areas. At this age the young are able to right themselves, but do little crawling until the eighth day, when they are strong enough to raise their now well-furred bodies off the ground. On the ninth day (Plate I) some of the youngsters can scramble quite quickly and use their hind legs for scratching. Coordination is improving, but all motion is still in twitches and jerks. Incisor teeth are first clearly seen at this age. Walking commences about the 11th day. The young, however, were not observed to walk voluntarily out of the nest until the 13th day. Eyes generally open on the 14th day, at which time the young become much more active. Green foods are first eaten at about this age, but suckling has been observed until the 19th day. Some litters have been successfully separated from their parents as early as the 17th day. Hamilton (1937), studying the more precocious *Microtus pennsylvanicus*, recorded weaning at 11–12 days. Once weaned, the offspring likely begin to wander away from the immediate vicinity of the nest and may be caught in traps.

As young are first born in the middle of June, and juveniles were first caught on 18 July, the age of these trapped juveniles was likely up to a month. A far younger animal was caught on 28 July. It weighed only 10.0 g which, from Fig. 1, indicates an age of 15–24 days. It seems, then, that phenacomys are first caught at the age of about three weeks but are not trapped in numbers for another week.

Figure 1 shows the average growth rate for the members of three litters. The range for each litter is also plotted. The phenacomys attained adult weight (i.e., curve leveled off) at about 27 grams in about 100 days. Hamilton (1937) recorded *Microtus pennsylvanicus* growth curves, showing a leveling of the curve at adult weight of 50 grams in about 100 days. Phenacomys initially average 2.4 grams in weight and *Microtus*, 2.07. Phenacomys gains less than ½ gram per day until over-half grown, while *Microtus* gains about one gram per day for the same period. Both attain adult weight in the laboratory in about 100 days. Hamilton found his laboratory data to be very similar to those gathered in the wild.

Morrison, Ryser and Strecker (1954) recorded a growth rate of .5 gram per day for the first 20 days for *Clethrionomys rutilus*—a figure more closely resembling phenacomys than *Microtus*. For a comparison of the morphological and behavioral development of the three species, see Table 1.

There appear to be no enemies peculiar to the young. Nests were found in dry situations and were little exposed to flooding or other detrimental physical factors. Only once was a young phenacomys (about 15 days old) found dead in a nest; a lactating female was caught in the same runway system at the same time.

Maturity.—From our data, it appears that the female becomes sexually mature before the male. In the paper of Foster and Peterson (1961), it

was shown that the measurement of the length of rostrum provided a fairly accurate gauge of the age of phenacomys and it was possible to see, in Fig. 4 of their paper, that eight of the juveniles (rostrum less than 8.2 mm) had become pregnant in their first summer. However, they produce fewer offspring than those in their second summer (Fig. 2). In this figure, the two clusters of points are separated at the same 8.2-mm length of rostrum as those in Fig. 4 (*op. cit.*). Clearly the lower group of points represents the younger animals (averaging 3.8 offspring) while the upper group (averaging 5.9 offspring) represents those at least one year old.

The earliest pregnant juveniles were trapped on 27 July. As the first pregnant female was trapped on 10 June, the juveniles appear to become sexually mature and may begin to breed at an age of 4 to 6 weeks.

However, the data show that males do not become fully sexually mature the first summer. In Fig. 3, length of rostrum is plotted against the length of testes. Again the two clusters of points appear to be separated approximately at the 8.2-mm length of rostrum. As Figs. 3 and 4 (Foster and Peterson, *op. cit.*) showed that all animals were in their second summer if their rostal length was more than 8.3 mm, then the upper group of voles comprises the year-olds mostly with large testes (about 6–8 mm), and the lower group juveniles with testes not greater than 4 mm (usually only 2 mm) in length. The question arises as to whether a male juvenile phenacomys with testes 4 mm long is capable of breeding. Hamilton (1937) failed to find

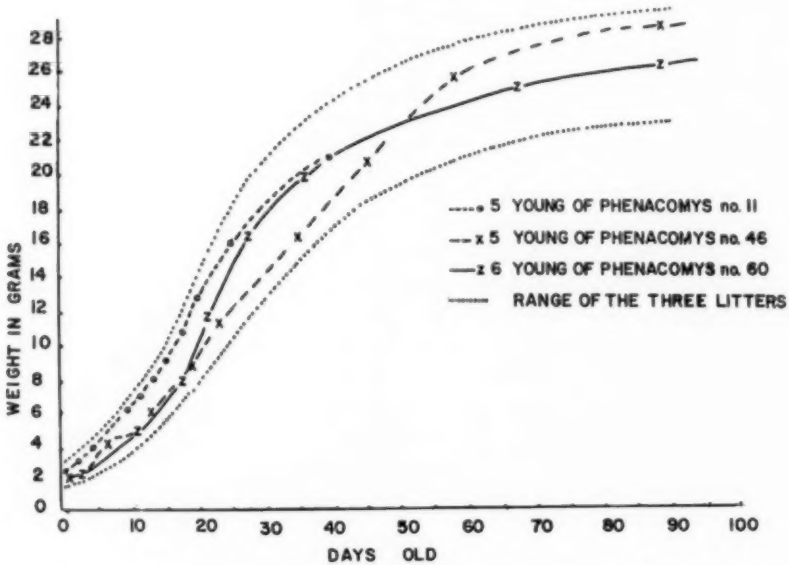

FIG. 1.—Mean growth curves for members of three litters born at Ft. Churchill.

TABLE 1.—*Comparative developmental rates of three species of microtines*

Day	*Phenacomys* (present study)	*Clethrionomys* (Morrison *et al.*, 1954)	*Microtus* (Cowan and Arsenault, 1954)
1	Body pink	Body pink	Body pink
2	Gray-pink dorsum	Gray-pink dorsum	Blackish back
3	Black dorsum	. . .	Hair tips showing
4	. . .	Hair seen	. . .
5	Flaked skin	. . .	Incisors
6	Velvet body	. . .	Crawling
7	. . .	Covered with red hair	. . .
8	Crawling	. . .	. . .
9	Incisors erupted	Incisors	. . .
10	Scrambling	Crawling	Eyes opening
11	Walking	Eyes open	Solid food
12	. . .	. . .	. . .
13	Walk out of nest	Solid food	Weaned
14	Eyes open	. . .	. . .
15	Solid food	Weaned	. . .
16	. . .	. . .	. . .
17	Weaned	. . .	. . .
18	. . .	. . .	. . .
19	Some still suckling	. . .	. . .

sperm in the epididymus of *Microtus pennsylvanicus* if the testes were smaller than 8×4 mm. The largest testes of *Microtus* were 20×12 mm. Our data indicate that male juveniles do not develop large testes, and likely are not capable of breeding their first summer.

Since the rostral measurement that separates juveniles from adults for both males and females is about the same, 8.2 mm, it appears that at this age the sexes differ little in size of rostrum. This is supported by comparing the evidence cited in Table 1, of Foster and Peterson (*op. cit.*) where Ft. Churchill and Authier-Nord populations show similar rostral lengths for the two sexes at both juvenile and adult age-classes.

Using the same Ft. Churchill material, the total length of body plus tail vertebrae was averaged for 82 males and 112 females. Males averaged 130.0 mm in total length, while females averaged 129.0 mm. In our material, there was a preponderance of young females (72:40) and old males (49:33) which would tend to lower the females' average, and raise the males'. Total-length measurements are less accurate than length of rostrum, and within the total length limits of ±5 mm, it seems that the sexes do not differ significantly in total length. Probably there is no significant difference in size between the sexes, for any given age.

It is reported (Foster and Peterson, 1961) that the laboratory phenacomys grew at a different rate than those in the field. The rostrum grew more quickly and the teeth more slowly in the colony. This was accounted for by the absence of low temperatures and the softer food provided for the captives.

BREEDING

During the three summers at Ft. Churchill, 15 litters were born in captivity and 28 snap-trapped phenacomys were pregnant. The total of 43 phenacomys bore 208 embryos or young. The average litter size was 4.8 (2–8).

It has been shown that young females born in the current summer averaged 3.8 offspring, while those born earlier averaged 5.9. The over-all average of 4.8 embryos would be influenced by the ratio of juvenile breeding females to adult breeding females in the population.

Four female phenacomys became pregnant in the laboratory. Two gave us a clue as to the length of gestation. One indicated a period of 21–24 days; the second, 19–24 days. Thus the duration of gestation is about three weeks, a figure comparable to that in *Microtus* (21 days: Hatfield, 1935) and in *Clethrionomys* (21–22 days: Morrison *et al.*, 1954).

The first and last gravid phenacomys were caught on 10 June and 3 September, respectively. However, as may be seen in Figs. 3 and 4 (Foster and Peterson, 1961), adults were only very rarely caught in September (5% of total taken), and thus our data fail to define the termination of

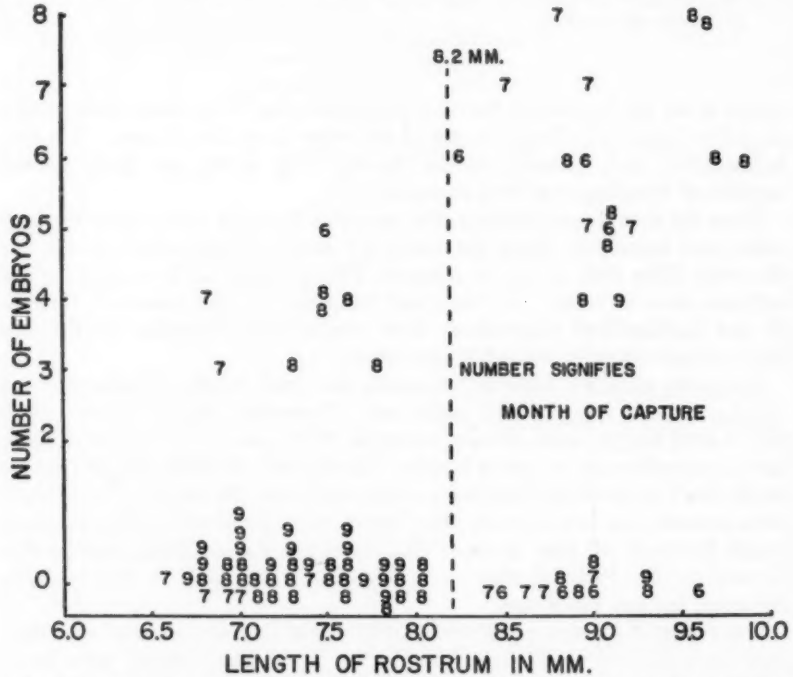

FIG. 2.—Relation between the length of rostrum and number of embryos for dead-caught Ft. Churchill phenacomys.

breeding. Interestingly enough, in spite of the great number of juveniles taken, none was found pregnant later than 13 August. Conceivably, the juveniles cease breeding for the season before the adults, for which there is a record as late as 3 September.

NEST

Only one report of the nest of *P. ungava* was found in the literature. Miller (1897), in Ontario, found a nest 10 inches below the ground at the end of a 2-foot tunnel in a rotten stump. Racey (1936), studying *P. intermedius* in British Columbia, found a nest containing two young at the base of a stump. He notes that the runways are not extensive, but rather are limited to the environs of nesting sites. Shaw (1924), studying *P. i. oramontis*, found that there are distinct summer and winter nests. The winter nest is a very conspicuous, neat, subsnow structure. One found was about the size of a robin's nest and was placed in the shelter of two rocks. Four others were close against the south side of rocks. The nests were usually lined with soft shredded blades of snow grass (*Juncoides*) and made snow-resistant by well-selected pieces of branching lichens. The framework was usually of "heather" twigs.

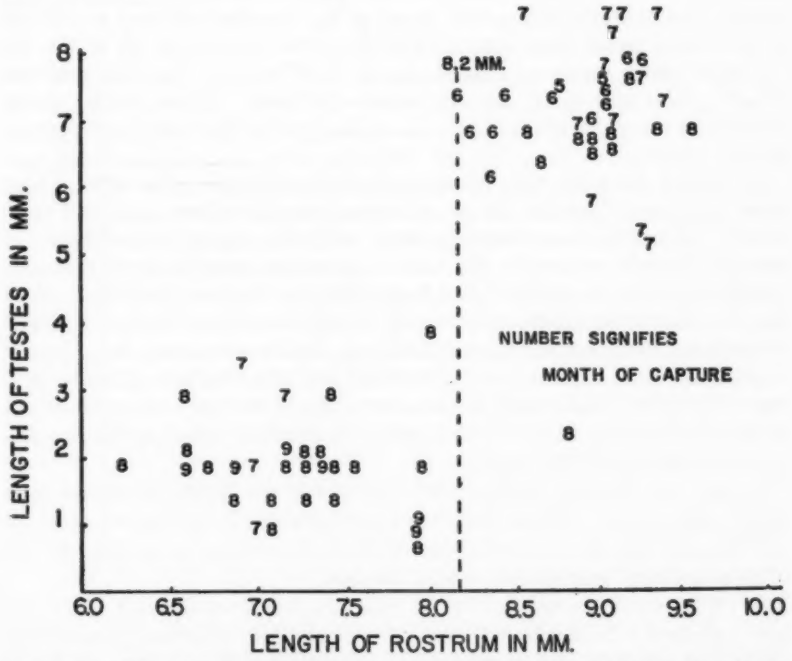

FIG. 3.—Relation between length of rostrum and length of testes for dead-caught Ft. Churchill phenacomys.

The summer nest of *P. intermedius*, according to Shaw, is underground. There is little evidence of its presence; even the hole is often overgrown. The nests were found scarcely below the surface of the ground and were constructed of grass, moss, and other materials. In one such nest Shaw found four young phenacomys. Shaw, like Racey (1936), observed that runways were indistinct and that tunnels were short.

At Ft. Churchill, both winter and summer nests were in evidence. The winter nests were about 6 inches in diameter, were constructed of leaves, twigs, grass and other vegetation, and were usually located above ground at the base of a willow bush, stump or rock. They were identified as the nests of *P. ungava* since 31 dead phenacomys were found in or beside such nests. They were presumed to be winter nests as they would offer little protection when the snow was gone, and never were they found occupied in the summer by live phenacomys.

The summer nests (Plate I), about 4 inches in diameter, bore a marked resemblance to those described by Shaw. During the three summers at Ft. Churchill, 21 occupied phenacomys nests were discovered. None was more than 8 inches below the ground; most were much closer to the surface. Eight nests were discovered immediately under a piece of cardboard or plank, while eleven were hidden under a rock, stump or log. Another nest was in a tangle of roots of a small white spruce. Twenty of the nests were all in the dry park-like spruce woods so typical around Ft. Churchill. The 21st nest was found a short way out in the dry hummocky tundra. It was buried almost 8 inches in the peat, not far from one of the frost cracks which are common in this habitat.

In general, the nests were constructed of the soft material at hand. Grass, moss and leaves lead the list of materials, but plant down, shredded cardboard and cotton from Sherman traps were also extensively utilized. In summer, tunnels connecting the nest to entrances were far from extensive, usually being no more than 3 feet long. However, in some habitats, such as the dry, hummocky tundra, ready-made tunnels were found along the bottom of partially filled cracks; these tunnels, no doubt, were used to a greater degree. No more than one nest was found per tunnel system. Usually there was a chamber for defecation within a foot of the nest. Paths were also scanty. Some plan-drawings of nests and tunnels are almost identical to the one illustrated in Shaw's (1924) paper.

Cowan and Guiguet (1956: 210), describing the habits of *Phenacomys intermedius*, wrote: "*Phenacomys* has been taken in the runways of *Microtus* and *Synaptomys*, in moist subalpine meadows but makes no runway system of its own except immediately around the nest."

At Ft. Churchill, no nest held more than one phenacomys except where one nest contained a dead youngster and a pregnant adult. Captives proved to be adults and subadults of both sexes. It seems strange that no nests were found containing a family of phenacomys. However, Shaw's work, and the discovery

of a dead 2- or 3-week-old phenacomys in its nest, suggests that the author merely failed to locate a brood nest, rather than that these nests are better hidden than others. No red-backed vole's nests were found though this vole was very plentiful.

At the Royal Ontario Museum, in the winter of 1956–57, 20 phenacomys were placed in two cages on the roof of the building. Each cage had two 1-foot cube wooden boxes filled with cotton for the mice to nest in. After three weeks, approximately 2,100 grams of willow twigs were carried into one box. These twigs still had their bark and were likely being used primarily for reinforcing the nests underneath, and secondarily as food.

Defecation is usually confined to one corner of the cage, often that corner farthest from the nest (about a foot away) and closest to the drinking tube. When a dish of water was placed in the cage, practically all feces were methodically placed in it. Some mice even defecated into the drinking tube. This habit of defecating in water could be an important factor in the transmittal of disease among phenacomys.

In conclusion, the summer and winter nests of phenacomys differ quite markedly. Tunnels and runways associated with the nest are usually less than 3 feet long. In these habits *P. ungava* and *P. intermedius* seem to be very similar.

HABITAT

The short-tailed group of *Phenacomys* is found in a far greater variety of habitats than any other within the genus. Both members of this group display similar diversified habitat requirements. Examination of the literature reveals an obvious inconsistency in habitat description. Some authors describe the areas in which the animals were taken (in vague or, sometimes, exact terms), while others describe the spot where the animal died. This makes analysis of the descriptions difficult. In spite of this variation in approach, some similarities of habitat can be detected.

The literature records *P. ungava* from a great variety of habitat types. Dry, open, pine-spruce situations seem to be preferred; situations near water may be more acceptable; an ample ground cover of the preferred foods likely denotes a superior habitat. Howell (1926) stated that the short-tailed forms live in extremely diverse habitats, but are usually found in dry situations where cover is ample. Saunders (1927), on the basis of specimens caught in eastern Canada, wrote that they occur in most habitats commonly found in the boreal forest. Edwards (1955) critically analyzed the habitats of the short-tailed forms and concluded that these two species prefer "open, seral forest vegetation in dry sites. Such sites near surface water seem to be superior. Lodgepole pine is usually associated with this mouse in British Columbia. Grasses may further denote superior habitat. There is some indication that brush heaps provide preferred cover." Apart from the reference to grass, my experiences are in accord with Edwards'. There seems to be no great habitat difference between the two species.

Negus (1950) wrote that "*Phenacomys intermedius* is more adaptable to varied habitats than are many of the other voles. It apparently survives well in moist or xeric conditions. This is not surprising when one considers that *Phenacomys* is one of the primitive vole genera, and might be expected to adapt itself more easily than some of the higher forms."

Habitat of PHENACOMYS UNGAVA

(*a*) Moisture conditions: In 20 literature accounts of the habitat, 75 per cent are described as dry or inferred to be so from plants that characteristically grow in dry localities (*Pinus banksiana, Arctostaphylos* spp., etc.); 29 per cent have open water (river, pond, etc.) in the near vicinity; and 20 per cent are described as being wet. At Authier-Nord and Ft. Churchill, the vast majority of voles were collected in dry habitats although, at the latter site, water was often close at hand; once the water table was only 2 inches below the moss. It seems that these phenacomys prefer dry habitats, though proximity to water may denote a superior location.

(*b*) Flora: As far as can be ascertained, all habitats described in the literature fall into the broad limits of the Canadian and Hudsonian life zones of Merriam. Forty per cent include spruce and/or pine in the description, 15 per cent mention sagebrush, *Vaccinium* or other members of the Ericaceae, while grass, poplar, willow, brush, sphagnum, etc. are only minor in the list.

At Authier-Nord, where an unusually high phenacomys population was encountered in 1953, but not in 1955, the site was a dry rocky hillside rather lightly covered with jack pine (*Pinus banksiana*) and occasionally broken by small valleys and patches of bush honeysuckle (*Diervilla lonicera*), alder (*Alnus* sp.), poplar (*Populus* sp.), chokecherry (*Prunus virginiana*), white birch (*Betula papyrifera*) and white spruce (*Picea glanca*). Ground cover was primarily of fruticose lichen (*Cladonia* spp.), blueberry (*Vaccinium angustifolium*), kalmia (*Kalmia angustifolia*) and bare rock.

During the same Royal Ontario Museum expedition to southwestern Quebec in 1953, eleven other phenacomys were caught in dry, park-like habitat resembling that of Authier-Nord, with blueberry, labrador tea (*Ledum groenlandicum*), or kalmia usually the dominant ground cover.

While most of the phenacomys caught in Quebec were confined to the one habitat, this was far from being the case at Ft. Churchill, Manitoba. Here, in 1954 and 1955, the voles were found in high numbers in a great variety of habitats. Damp sphagnum spruce forests, dry spruce woods, dense willow thickets, willow tundra miles from the treeline, dry, hummocky, *Cladonia*-heath tundra, wet mossy meadows and willowy levees all supported at least a few phenacomys. They were not taken in pure grassy patches, nor on tundra which did not provide shelter with hummocks, frost cracks, pond edges, etc. Phenacomys seemed to live wherever it could find suitable food (*Arctostaphylos rubra, Salix* spp., *Shepherdia canadensis* and *Empetrum nigrum* are especially important) and shelter in the form of bushes, logs, stumps, hummocks, frost cracks, etc. Phenacomys were unusually numerous

these years and might well have dispersed into habitats unusual for the species. Conversely, pressure from related species (red-backed vole, meadow vole, and varying lemming) might have deterred phenacomys from entering those habitats where it was not found. Living in grass seems unlikely, as phenacomys only occasionally ate grass in the laboratory and it is doubtful that they could secure adequate food in a pure grass habitat. Also, phenacomys have always been found in habitats with some cover, and likely the "bald" tundra would be unsuitable. No phenacomys were found on the truly arctic expanse at Cape Churchill.

In the laboratory, two 3-foot square boxes were built and joined by a short 1-inch tube, so placed that the voles could easily pass from one side to the other. Different kinds of food and cover were placed in each side and the voles were allowed to select the preferred side. The voles consistently selected the side with the greatest cover, and also preferred edible to non-edible cover.

Habitat of PHENACOMYS INTERMEDIUS

In 43 habitat descriptions in the literature, dryness is mentioned in 80 per cent, proximity to water in 29 per cent, wet habitats in 20 per cent, spruce and pine in 32 per cent, treeline (Krumholtz) in 23 per cent, grass in 16 per cent, and sagebrush and "heather" in 11 per cent.

Brush heaps are mentioned in 16 per cent of the descriptions; they could have been overlooked in others. Forests are usually inferred to be "open." The percentages are remarkably close to those describing *P. ungava*. All habitats described fall within the broad limits of the Canadian and Hudsonian life zones. "Treeline" is mentioned frequently in the descriptions of *P. intermedius*, probably because the Canadian–Hudsonian zones are narrow on many mountain slopes and phenacomys might range beyond this line.

FOOD

Winter.—No reference to the winter food of *P. ungava* could be found. However, writing of *P. intermedius*, Shaw (1942) noted, "If one looks very closely near the winter nest, one will find bits of the denuded twigs of white heather, indicative of the winter food. Beargrass was once found which had been used for food. The red heather seems not to be taken."

At Ft. Churchill, evidence of the winter foods of phenacomys was gathered by examining the habitat in the spring just after the snow melted, and by studying stomach contents of the voles at this time.

During the springs of 1954 and 1955, it was observed that scarcely a twig of any willow bush (*Salix* spp.) retained its bark; some dwarf birch bushes (*Betula glandulosa*) were similarly depredated. Short, denuded willow twigs were often found in piles by bushes, unused nests and entrances to burrows. As phenacomys and the red-backed vole were the commonest mammals in our catches, they are considered responsible for most of the damage. Hence it appears that phenacomys lives, at least in part, on the bark of willow and possibly dwarf birch during the winter.

The contents of five stomachs collected in May indicate a preference for bark. Crushed seeds and possibly lichens (*Cladonia* sp.) were also identified. No doubt some berries and seeds are eaten, especially in the early winter when these foods are more plentiful. The bark of many ericaceous plants, similar to those referred to by Shaw (1924), are also eaten.

Summer.—Miller (1897), trapping *P. ungava* on blueberry barrens, noted catches of blueberry (*Vaccinium* sp.), bearberry (*Arctostaphylos uva-ursi*) and other shrubs near one nest. The succulent parts of *Potentilla tridentata* were also found.

Phenacomys at Ft. Churchill and elsewhere frequently collect succulent herbage and leave it in piles at the entrance to their burrows, occasionally almost plugging them. Such collections are useful in determining the voles' presence as well as its diet. This habit is also found in *P. intermedius*. Shaw (1924) reported, "The summer provender is selected with great care as to succulency and one may find clusters of the stems of lousewort (*Pedicularis*) and freshly cut huckleberry leaves at the entrance of the burrows." Bailey (1936) reported *P. intermedius* mainly feeding on green grass, low vegetation, bark, leaves and twigs. Racey (1936) examined two food caches of *P. intermedius* in British Columbia which contained bearberry, soapolallie, wild rose, vetch and traces of aspen and strawberry. Edwards (1955) in British Columbia noted stomach contents smelling strongly of crushed grass.

Cowan and Guiguet (1956: 210), also considering *P. intermedius*, wrote: "Food a variety of vegetation, but the leaves and berries of bearberry are most important summer and winter and make up 85–90% of the diet; *Shepherdia canadensis* makes up 6%; *Rosa*, *Viccia* [sic] and others 5 to 10%. Often small piles of the leaves and fruits of bearberry are accumulated in hollows in logs and the stumps of dead trees." These notes resulted from examination of food piles exclusively.

Numerous food piles of phenacomys at Authier-Nord, Quebec, included *Vaccinium angustifolium* and *Kalmia angustifolia*. *Shepherdia* and *Arctostaphylos* were not present in the flora, and therefore could not be used for food.

From the summer field and laboratory work at Ft. Churchill, the following conclusions may be drawn:

1. Species of plants frequently encountered in food piles included the willows (*Salix arctica*, *S. arctophila*, *S. cordifolia*, *S. candida*), bearberry (*Arctostaphylos rubra*, *A. alpina*), blueberry (*Vaccinium uliginosum*), soapberry (*Shepherdia canadensis*) and dwarf birch (*Betula glandulosa*).

2. Less common species in caches were crowberry (*Empetrum nigrum*, Plate I), fireweed (*Epilobium angustifolium*), bog-rosemary (*Andromeda glaucophylla*), willow (*Salix reticulata*), mountain cranberry (*Vaccinium vitis-idaea*), and baked appleberry (*Rubus chamaemorus*).

3. Other wild plants eaten in the laboratory included caribou moss (*Cladonia* spp.), a species which does not lend itself to collection by voles

due to its structure, *Polygonium vivipore, Hedysarum mackenzii, Ledum* spp. (apparently only flowers), *Cypripedium passerinum* (seed pods), and grasses and sedges (only slightly). All common berries were eaten except those of baked appleberry.

4. Domestic foods included carrots, apples, turnip, yam, rolled oats, and raisins. Peanut butter, peanuts, and cheese are regularly eaten by some phenacomys. Animal food pellets, lettuce, and cabbage are not eaten.

5. The relative amounts of each food found in caches seem to depend to a large extent on availability. During one summer (1955), the 215 food caches on one 3-acre woods plot contained willow (68%), blueberry (9%), soapberry (9%), dwarf birch (6%), bearberry (6%), crowberry (1%), and fireweed (1%). In other localities where soapberry was more plentiful, it often comprised 50 per cent of the food in caches. Similarly, bearberry was locally more abundant in food caches than in the above sample. Soapberry seems to be eaten more during the fall than the summer, especially when the willow leaves begin to fall.

6. Phenacomys were never observed eating animal matter, although some microtines are quite carnivorous and cannibalistic.

Food caches.—The habit of establishing food caches has been referred to previously. In the wild, *P. ungava* makes such caches both in winter and in summer. In the laboratory, food caches are also observed at all times of the year. Caches probably fulfill the dual purposes of permitting the voles to eat in a shelter remote from both its enemies and the elements. The latter would be especially important in winter. This habit seems to be more highly developed in both *P. intermedius* and *P. ungava* than in any of the other microtines. At Ft. Churchill, the field vole (*Microtus*) was thought occasionally to make food piles of fresh grass in its burrows; rarely did it attempt to do this in the laboratory. The red-backed vole (*Clethrionomys*) occasionally made food caches in the laboratory. In the woods, caches of fireweed (*Epilobium*) were occasionally discovered. As fireweed is a species of plant that *P. ungava* apparently does not eat, and the red-backed vole does, these caches likely belonged to the latter.

From our experience, and supported by the literature, it seems that neither the field nor the red-backed vole makes food caches as readily as does *Phenacomys*. Some of the long-tailed forms of *Phenacomys* also make food caches (Howell, 1926); thus it is possibly characteristic of the whole genus.

Howell (1926: 11) wrote, "Rooted (brachyodont) molars are more suitable for crushing soft and brittle foods, as seeds. It thus seems probable, but is as yet unproved, that the food of *Phenacomys* on the whole is of a character more nearly comparable with that of the majority of the Cricetinae than it is with that of *Microtus*." While it is true that most of the summer food of *P. ungava* is soft or brittle, winter foods are often tough and coarse, such as willow bark, an important winter food item.

ENEMIES

Predators.—Phenacomys have many predators for which we lack specific data. Owl and hawk pellets collected at Ft. Churchill in the summers of 1955–1956 contain 522 complete or partial skulls. Of these, 85 skulls (43 varying lemmings, 40 field voles, 2 muskrats) were collected 30 miles to the east of the Fort on Cape Churchill. The absence of phenacomys skulls from the Cape suggests that this species has not been abundant out on this truly arctic expanse in recent years.

The remaining 437 skulls, collected near Ft. Churchill, include 153 varying lemmings (*Dicrostonyx groenlandicus*), 139 phenacomys, 134 field voles (*Microtus pennsylvanicus*), 9 red-backed voles (*Clethrionomys gapperi*), one red squirrel (*Tamiasciunus hudsonicus*), and one bog lemming (*Synaptomys borealis*). They are thought to have been deposited primarily from 1953–1955, as both avian predators and microtines were plentiful during these years, while both were scarce by the summer of 1956. Short-eared owls (*Asio flammeus*), snowy owls (*Nyctea scandiaca*), hawk-owls (*Surnia ulula*), and rough-legged hawks (*Buteo lagopus*), in order of decreasing importance, are thought to be responsible for the pellets. Fresh carcasses of phenacomys were also observed in the talons or at the nests of both hawk-owls and short-eared owls.

The results of trapping during these three summers are not wholly compatible with the pellet findings. Killed in traps near Ft. Churchill were 447 red-backed voles, 207 phenacomys, 38 field voles, 13 lemmings, and 6 bog lemmings. As most of the trapping was confined to woods and brush, field voles and lemmings were uncommonly caught. Nine red-backed voles in owl pellets versus 447 in traps are the primary conflicting data. Red-backed voles were found to outnumber phenacomys in the trap-line catch in almost every area trapped, yet were much less frequent in the pellet analysis. Possibly this is adequately explained by the differences in behavior of the two voles. Field evidence shows the red-backed vole to be more cautious than phenacomys. The former was rarely observed in the field, while the latter was observed on at least ten occasions. Trapping results show red-backed voles to be more active during daylight hours than phenacomys and, at the same time, more numerous. Thus from field data we conclude that phenacomys are less wary than red-backed voles. Laboratory observations support this view. Whether behavior alone is sufficient to account for the difference in numbers caught by owls and hawks is a moot point.

Parasites.—Until recently, no parasites had been reported from *P. ungava*. Harper (1956), at the treeline about 200 miles northwest of Ft. Churchill, found about 13 specimens infested with acarine mites.

At Ft. Churchill, parasites were collected and sent to specialists for identification. G. P. Holland, Department of Agriculture, Ottawa, identified four species of fleas collected from phenacomys: *Megabothris quirini* (Rothschild), *M. groenlandicus* (Wahlgren), *Malaraeus penicilliger athabascae* Holland,

and *Peromyscopsylla h. hamifer* (Rothschild). In 1953, phenacomys at Authier-Nord were highly parasitized with *Cuterebra* sp.

Diseases.—All phenacomys that died in captivity were examined for cause of death. Almost every individual showed signs of diarrhea, with the entire digestive track full of gas. Many had one or both eyes closed before death. Other internal organs appeared normal. *Listeriosis* was isolated from a brain sample of one specimen by E. Kuitunen of the Ontario Health Laboratories; this may have caused death in many of the voles. Attempts to discover *Listeriosis* in the brains of those phenacomys found dead at Ft. Churchill were unsuccessful. The 31 phenacomys found dead in the wild were either in or beside their winter-type nests. There was no suggestion of drowning; most of the nests were above the spring water level. Skull analysis showed that no one age-class predominated in the carcass count. The carcasses of 14 lemmings, 4 field voles, and 1 red-backed vole were discovered in the same period. A greater proportion of phenacomys than of other Ft. Churchill microtines appeared to be dying of some disease during the winter period.

BEHAVIOR

P. ungava is one of the most docile small mammals. When first captured, it never tried to bite and rarely made any determined effort to escape. It soon became accustomed to a cage and continued its activity with little heed to observers. It appears that all members of the genus are comparatively docile (Walker 1930, Howell 1926).

Interaction.—In the Ft. Churchill colony, no one species appeared dominant over another. Generally the voles seemed to avoid encounters with others. Occasionally a phenacomys was found sleeping in the same nest (but a few inches apart) from one of the other species even though there was a second empty nest present.

The behavior was different if the phenacomys had young. In such a case, the female viciously routed the red-backed or field vole or its own species of either sex.

In the laboratory during the winter, as many as five phenacomys were found sleeping in one nest. Fights were never observed during this season.

Phenacomys quite often engage in combat during the breeding season. The fiercest battles are among males. Five males received injuries in such fights, all in the form of a bitten rump or tail, or a missing toe. As wild-caught mice, even those from the high Authier-Nord population, were never found to suffer from such injuries, it may be concluded that regular fights and resultant injuries are attributable to laboratory conditions.

Swimming.—Peterson (1955) reported three phenacomys identified from the stomachs of speckled trout (*Salvelinus fontinalis*) from Sutton River, Ontario, 54° 40′ N, 84° 35′ W. A. T. Cringan, who forwarded the mouse remains to Peterson, noted a very dense mouse population at this locale. "The mice had even levelled small clumps of willow two to three feet in height." As phenacomys apparently is not morphologically adapted for swimming, it seems likely that

population pressure forced mice to seek new country, even by swimming across water, and that capture by fish is not common during most years. Laboratory tests indicate that phenacomys can swim reasonably well but try to avoid doing so.

Activity.—Our trapping data indicate that phenacomys is more active during twilight and/or night than by day, and that the red-backed vole is more diurnal than phenacomys. The latter might appear to be less active during the day than red-backed voles because of its habit of collecting and storing food near its nest. Much of this supply is collected during the 14 twilight hours and could supply sufficient food until the next evening. However, as noted earlier, phenacomys are far more frequently seen during daylight hours than are red-backed voles. Both species were frequently caught and recaught at the same hole.

In September 1955, five different phenacomys were placed in activity wheels which were connected to Easter-Line Angus Recorders. At this time of year there were about 9 hours of darkness. The animals only rarely ran during daylight hours, and then for only a few turns, but ran many turns in darkness. However, they were frequently seen feeding during the day. This supports the earlier evidence that at night the voles gather food, run about, build nests, etc., while during the day their activity is reduced but not eliminated.

On some mornings, piles of fresh willow were plentiful in the woods, while on others they were sparse or absent. From a month's observations in one area, it was quite clear ($P = .001$) that willow was gathered in greater quantity on rainy, foggy, or windy nights than on clear, still nights.

In 1955, some phenacomys were toe-marked and released. Recapture was rarely accomplished. An old male was recaptured 600 yards north of its orignal capture point 16 days after marking. No marked voles were caught the following summer.

Population fluctuation.—Comparable trapping data at Ft. Churchill are available for the years 1951–1957, inclusive. The years 1951–1955 are discussed at length by Smith and Foster (1957). In 1951, Smith caught no phenacomys in 610 trap-nights in the Ft. Churchill area. All microtines appeared extremely scarce. In 1952, he caught two phenacomys and 79 other small mammals (2,427 trap-nights). H. L. Gunderson (personal communication) in 1953 caught 6 phenacomys and 12 other microtines (575 trap-nights). This population increase, began in 1952, continued its trend through 1954 (the author caught 68 phenacomys and 273 other voles in 2,300 trap-nights), and in 1955 (the author caught 192 phenacomys and 495 others in 8,700 trap-nights). In 1956, the 5,611 combined trap-nights of the author and of Walter Gillespie (personal communication) caught 82 phenacomys, other mammals being proportionately scarce. George West (personal communication), trapping near Ft. Churchill in 1957, caught one phenacomys in 1,214 trap-nights. Gillespie, trapping near Ft. Churchill at Ilford, Thicket Portage, Herriot Creek, and Gillan during the same summer, failed to catch any phenacomys. It

appeared that in 1957, the phenacomys population had returned to its 1951–1952 level.

In general, trapping for *P. ungava* throughout its range has met with little success until lately. High populations have been discovered near Ft. Chimo (Bateman, 1953), Sutton Lake (Peterson, 1955), Authier-Nord, and Ft. Churchill. *P. intermedius* is also considered uncommon within its range. Edwards (1952) queried whether snap-traps or unattractive bait might account for the lack of trapping success. In his experience, *P. intermedius* was commonly caught in bucket traps and was once found in numbers mired on a freshly oiled road. Snap-trapping nearby caught few or no phenacomys. I contend that the trapping procedure may be in error: that by trapping immediately in front of holes that exhibit the vole's workings, a higher trapping success will be acheived.

ACKNOWLEDGMENTS

The bulk of the present research was carried out at Ft. Churchill during the summers of 1955 and 1956 and at the Royal Ontario Museum during the winters. This work was supported by grants from the National Research Council of Canada to Dr. R. L. Peterson of the Royal Ontario Museum, Toronto. To the National Research Council, the Royal Ontario Museum, the Defence Research Board at Ft. Churchill, Dr. R. L. Peterson, R. M. Bateman, and the many others who gave considerable aid, the author wishes to express his sincere gratitude.

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SEASONAL VARIATIONS IN THE HEMATOLOGY AND PHYSIOLOGY OF BLACK BEARS

By Albert W. Erickson and William G. Youatt

Abstract: During 1956 and 1957, four black bears (*Ursus americanus*) were held captive in northern Michigan. They were dormant in winter quarters from approximately 25 December to 17 April, during which time all lost weight. Four times over a 9-month period the bears were anesthetized and various physiological and hematological values were obtained.

One aspect of a recent study of the black bear, *Ursus americanus*, in Michigan involved seasonal variations in certain physiological and hematological values. We wanted to determine what variations occurred in some of the metabolic processes during the overwintering period of torpor, or dormancy, of black bears.

During 1956–57, four captive wild bears were held at the Cusino Wildlife Experiment Station, near Shingleton, Michigan. Two were subadult females, one a male cub and the other an adult male. The animals, in individual pens with dens and straw bedding, were maintained on a well-balanced commercial dogfood ration. All bears winter-denned from 25 December to 17 April with the exception of bear *A*, which entered the den on 26 November, and bear *D*, which emerged from its den on 1 April.

The bears were anesthetized with pentobarbital sodium (1 grain/cc) four times in nine months, including twice during the overwinter period of torpor. Anesthetic injection was accomplished by first rendering the bears helpless by intramuscular injection of the muscle relaxant, succinyl choline chloride. About 30 minutes after anesthesia, studies of physical condition were made and blood samples of about 10 ml each were collected from the jugular vein in vials containing the dried equivalent of 1 ml of oxalate solution (4.8 gm ammonium oxalate and 3.2 gm potassium oxalate in 1000 ml HOH).

Weights were taken on a Chatillon (300-lb capacity) wall-mounted scale, temperatures were taken rectally, and pulse was determined by palpation over the heart. Packed cell volumes were determined with a Wintrobe hematocrit tube. Hemoglobin (direct method), blood sugar, total protein, albumin, globulin, phosphorus, and chloride were determined with a Fisher Clinical

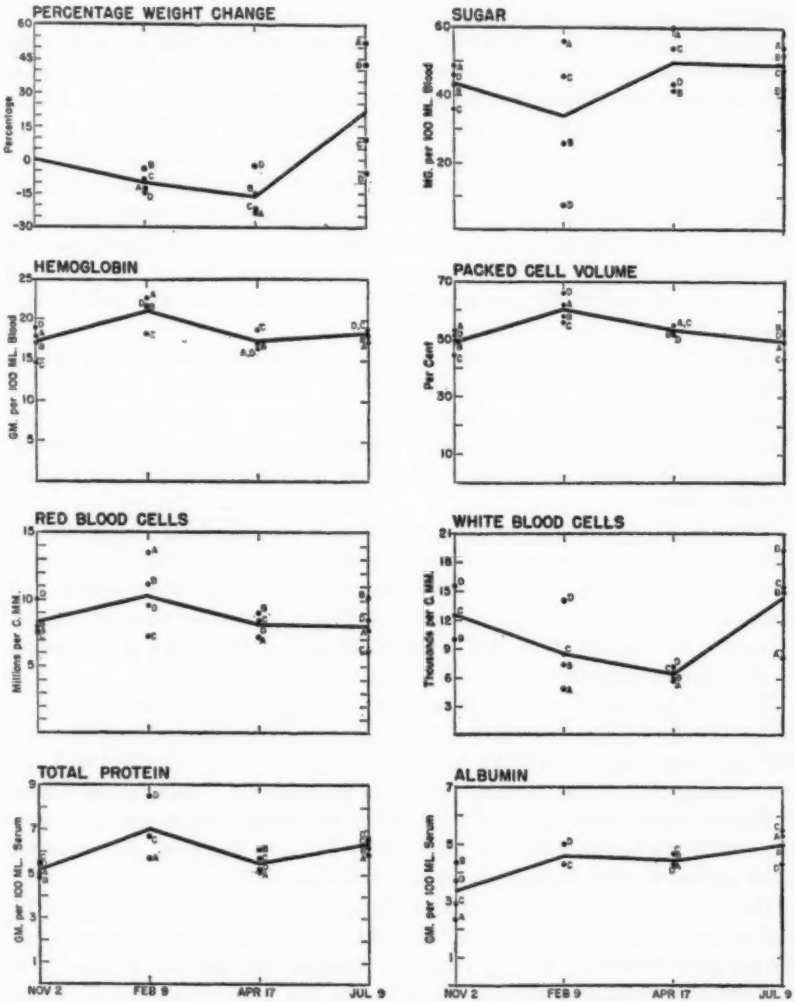

FIG. 1.—Graphs of factors varying with the seasons.

Electrophotometer using methods described in the Fisher Manual (1952). The results are presented in Table 1 and Fig. 1.

Physical changes noted seasonally.—Marked seasonal weight changes were observed in all four bears (Table 1, Fig. 1). A slight but progressive weight loss occurred during torpor. From 2 November to 9 February the mean weight loss was 9.4 per cent. Maximum and minimum percentage losses for this period were 14.1 and 3.4, respectively. Presumably these losses occurred during early dormancy since the bears were fed until denned.

By 17 April, the mean body weight loss increased to 15.6 per cent. The mean weight loss sustained by these bears during dormancy was actually even greater, since bear *D* emerged from dormancy 17 days before the April weighing and gained substantial weight. By February it had lost 14.1 per cent of its November weight, yet in April, doubtless because of its feeding after awakening, it weighed only 3 pounds less than it had in November. Weight losses for the remaining three bears over the November–April period amounted to 15, 22 and 23 per cent, respectively. These losses are considered minimal for torpid bears since the denning period was shortened by delaying denning for bears *B*, *C* and *D* by continued feeding until 23 December, and by disturbing the animals for handling in April.

These data indicate that non-parous black bears in this latitude, even though not true hibernators (Lyman and Chatfield, 1955), sustain overwintering weight losses of about 20 per cent during dormancy. A similar weight loss has been reported for the woodchuck (*Marmota monax*), a true hibernator, also dependent solely upon fat as its energy source during dormancy (Rasmussen, 1916).

Bear *D*, which emerged early from dormancy, sustained the largest weight loss between November and February. This may indicate that the physical condition in which bears enter the winter dens influences the duration and time of their emergence from dormancy. This is consistent with the theory advanced by Grinnell *et al.* (1937) which states that the length of the period of dormancy is regulated by the abundance or scarcity of food.

The weight loss of each bear was readily regained following dormancy (Fig. 1). By 9 July, the mean weight gain from the mean winter low was 55.7 per cent. Bear *A*, now 1½ years of age, gained an astounding 98.5 per cent during this period. While these data demonstrate a remarkable ability of bears to make large short-term weight gains where food is provided, it is improbable that such gains are realized by bears in the wild, since natural foods appear limited during this period (Erickson, 1957).

The July body temperatures of these bears were similar (Fig. 1, Table 1) and averaged 98.6°F. It is assumed that this represents the temperature norm during non-dormancy. During torpor, a temperature depression from 3 to 4 degrees apparently occurs, as indicated by the 95.3°F average February readings obtained for bears *A* and *B*. The two pulse determinations which

TABLE 1.—*Variations in hematology and physiology of black bears at four seasons*

BEAR	AGE and SEX	Wt, lb	HBG gm/100 ml	WBC 1,000/cmm	RBC million/cmm	TEMP, °F	PULSE	PCV %	SUGAR mg/100 ml blood	TOT PROT gm/100 ml serum	ALB gm/100 ml serum	GLOB gm/100 ml serum	PROS mg/100 ml serum	CHLOR mg/100 ml blood
Dates			2 Nov. 56						9 Feb. 57					
A	Juv ♂	90	17.8	–	7.88	102.6	–	52	49	5.0	2.4	2.6	4.0	320
B	Yrl ♀	113	17.2	9.80	8.06	–	–	49	43	4.8	4.4	0.4	6.0	420
C	Adl ♂	252	14.6	12.40	7.76	–	–	44	36	5.5	2.9	2.6	5.0	450
D	Yrl ♀	128	19.0	15.40	10.00	–	–	51	46	5.4	3.7	1.7	6.7	375
Avg.		146	17.2	12.53	8.43	–	–	49	44	5.2	3.4	1.8	5.4	391
A	Juv ♂	79	22.7	4.95	13.50	95.9	144	62	56	5.7	–	–	1.9	410
B	Yrl ♀	109	21.5	7.30	11.10	94.6	96	58	26	–	–	–	–	330
C	Adl ♂	232	18.3	8.70	7.14	–	–	56	46	6.7	4.3	2.4	–	–
D	Yrl ♀	110	21.7	14.10	9.59	–	–	66	–	8.5	5.0	3.5	–	–
Avg.		133	21.1	8.76	10.33	95.3	120	61	42.7	7.0	4.7	3.0	–	370
A	Juv ♂	69	16.6	5.90	7.13	–	–	55	60	5.1	4.4	0.7	5.0	500
B	Yrl ♀	96	17.2	6.05	9.01	–	–	53	42	6.1	4.4	1.7	4.8	340
C	Adl ♂	197	13.8	6.55	8.46	–	–	55	54	5.7	4.7	1.0	5.2	440
D	Yrl ♀	125	16.6	7.00	8.21	–	–	51	44	5.2	4.3	0.9	6.4	360
Avg.		122	17.3	6.38	8.21	–	–	54	50	5.5	4.5	1.1	5.4	410
A	Juv ♂	137	17.3	8.20	7.75	98.8	122	49	54	5.9	5.3	0.6	8.3	300
B	Yrl ♀	161	18.0	15.00	10.17	98.4	176	53	52	6.2	5.0	1.2	9.1	660
C	Adl ♂	289	19.0	15.50	6.06	98.6	134	43	48	6.5	5.5	1.0	7.9	420
D	Yrl ♀	121	19.0	19.40	8.56	98.4	118	52	42	6.6	4.3	2.3	7.9	200
Avg.		177	18.3	14.53	8.14	98.6	138	49	49	6.3	5.0	1.3	8.3	395

could be made in winter (Table 1) yielded one low reading and one within the range of summer variations.

Hematological changes noted seasonally.—Although our data are too few to evaluate possible seasonal differences for all of the hematological factors involved for these bears, several were investigated sufficiently to demonstrate variations. The only marked deviations, however, occurred during early torpor. At that time a substantial increase was noted for circulating erythrocytes, with corresponding increases noted for hemoglobin, packed cell volumes, and total protein. These same factors near the end of winter dormancy revealed values similar to those for non-dormancy (Table 1, Fig. 1).

Similar increases of circulating erythrocyte counts, hemoglobins and packed cell volumes during hibernation have been reported for the ground squirrel (*Citellus parryi*) by Svihla and Bowman (1952) and by Svihla *et al.* (1953), and for the golden hamster (*Mesocricetus auratus*) by Suomalainen and Granstrom (1955) and by Lyman *et al.* (1957). Rasmussen (1916) noted a slight increase in circulating erythrocytes for the hibernating woodchuck but a lower hemoglobin for animals in a semidormant state than for those in deep hibernation. On the other hand, Stuckey and Coco (1942) noted a 37.9 per cent decrease in circulating erythrocytes and a 25.7 per cent decrease in hemoglobin for hibernating ground squirrels (*Citellus tridecemlineatus*). The biological significance of these conflicting reports awaits explanation. The results noted in the present study indicate marked changes in these factors during early torpor and a shift back to non-dormant values in late torpor. The differences noted in the literature may be due to data having been taken at different times within the hibernating period. This would appear especially likely for animals which periodically awaken during hibernation.

The pronounced leukopenia noted for our bears during torpor (Table 1, Fig. 1) was reported in all of the previously cited works and appears to be characteristic of all true hibernators (Lyman *et al.*, 1957). Other blood determinations in this study, however, are difficult to interpret because of the variations exhibited or because of inadequate data.

Blood sugar is of especial interest. In two bears, blood sugar increased during torpor and in the other two it decreased. Previous blood sugar determinations for black bears (Youatt and Erickson, 1958) also showed considerable variation. Sugar determinations for these captives during summer were appreciably below those for wild bears. Presumably the latter's sugar values were inflated by energy-rich foods such as berries and fruits, available to them at this time. Varied blood sugar values have been reported for other species during hibernation, indicating this is a highly variable factor among hibernators (Lyman and Chatfield, 1955; Stuckey and Coco, 1942; Lyman, 1943). Lyman and LeDuc (1953) suggest that the reported differences in this factor may be due to differences in the habits of the animals. Thus, in those forms utilizing only fat for energy, such as the woodchuck, a much greater decline of blood sugar results than in those forms, such as the hamster,

which periodically awaken to feed. The results of the present study tend to support this hypothesis and to place the bear in the category of semihibernators.

Although only one determination was obtained for blood phosphorus during early torpor, it possibly indicates that a marked decrease occurs at that time. Blood phosphorus levels during July were consistently higher than were the comparable values for November and April. Chloride determinations showed little seasonal variation.

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[A joint contribution of Federal Aid in Wildlife Restoration Project W-70-R, Cusino Wildlife Experiment Station, Michigan Department of Conservation, and of the Department of Fisheries and Wildlife, Michigan State University. Submitted by the senior author as a portion of a dissertation in partial fulfillment of the requirements for the Ph.D. degree at Michigan State University.]

NOTES ON COUGAR PRODUCTIVITY AND LIFE HISTORY

By W. Leslie Robinette, Jay S. Gashwiler and Owen W. Morris

Abstract: Records collected principally from 1946 through 1958 in Utah and Nevada have shown that the cougar may have young any month of the year. However, birth months, as determined by reference of juvenile weights from 145 litters to a growth curve, indicated that about 60 per cent of the litters were probably born from June through September with a peak in July. The highest incidence of pregnancy for 199 mature females was noted in June and July. Forty-one per cent of 299 mature females had young at the time of capture.

Evidence is presented that some females apparently have young as often as 12–15 months, but a 2-year interval appears the rule. Most young apparently remain with their mothers for at least a year.

The average size of 258 postnatal litters was 2.9 (range, 1–5) and of 66 prenatal litters it was 3.4 (range, 1–6).

It is generally recognized that the cougar, *Felis concolor*, may have its young any time of the year and that litters number mostly from two to four. Records and observations given in this paper for Utah and Nevada are generally corroborative of the literature, but are more specific.

METHODS

From 1946 through 1958, cougar hunters were contacted at frequent intervals from November to March, when most of the hunting is done and when cougar carcasses are most likely to be brought in from the mountains. When convenient, the carcasses were weighed and measured and the female reproductive tracts examined for pregnancy or removed for further study. Hunters were queried as to whether females were nursing or had been accompanied by young and, if so, how many, in the event the entire litter was not taken. Federal hunters who regularly took the most cougars were supplied with forms on which to record the desired information for each animal taken, as well as jugs with formalin solution in which to preserve reproductive tracts. Size records of many additional prenatal litters were obtained from past reports of the federal hunters.

Limited information on cougar ovulation rates was obtained by sectioning ovaries at 1–2 mm intervals with a razor blade and counting, by gross examination, the corpora lutea and large Graafian follicles.

RESULTS

Growth.—To determine the probable birth months of litters (discussed in a later section) it was desirable that a growth curve be developed. Few reliable weights for cougars of known ages are listed in the literature. We attempted periodic weighings of young from two litters captured in Utah, but poor condition of the animals indicated subnormal weight gains, so the records were of limited value.

The growth curve in Fig. 1 was developed from a few records of known-age cougars plus the probable weights by sex at maturity. Conformation of the resulting curve closely approximated that for a captive black leopard weighed weekly from birth to maturity (Grace Davall, *in litt.*, 1953) after corrections for differing weights and probable ages at maturity for the two species had been made.

The following information was used in developing the cougar growth curve:

Maloit (MS report, 1949) gave the total length of a male fetus (from a litter of two and believed within one or two weeks of term) as 35 cm (14 inches) and the eviscerated weight as 360 grams. By extrapolation from a curve of fetal weight over total length, we derived an estimated total weight of 400 grams for this fetus. It seems probable that it would have approached a birth weight of about one pound, which Young and Goldman (1946: 115) indicate as maximum for the species. In addition, Young and Goldman (*op.*

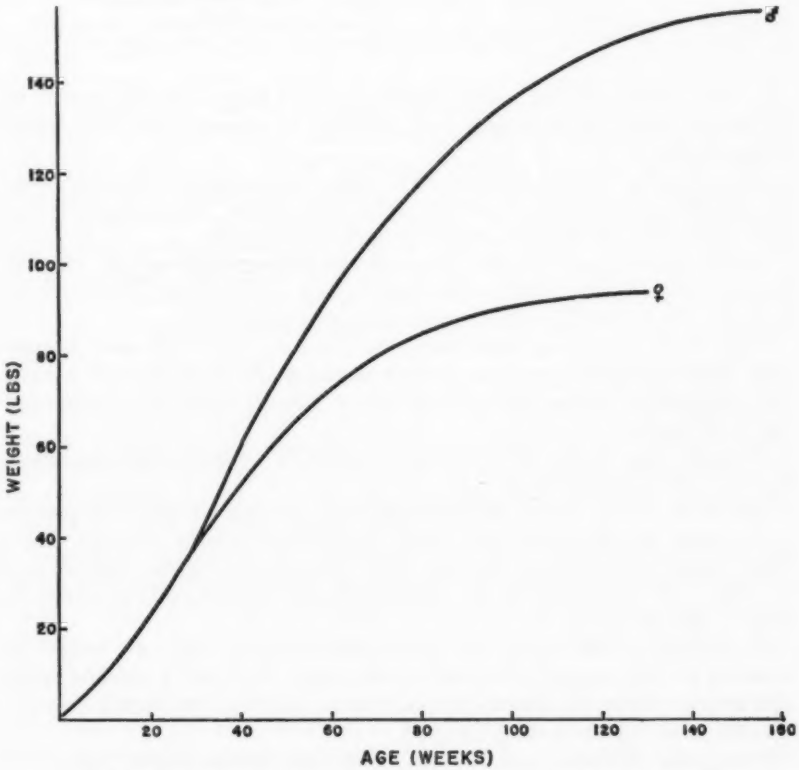

FIG. 1.—Growth curve (weight over age) for cougars from birth to maturity.

TABLE 1.—*Weights, actual or estimated, of juvenile cougars from litters containing both sexes*

Males	Females
1.75 lb	2.25 lb
6	6
9	9
23	20,21,22
30 (est)	20 (est)
32	24
32	32
40	35
45	45.5
51	50
60,60	50 (est)
69	63
70–75 (est)	55–60 (est)
75–80 (est)	60–65 (est)
94	69,51

cit.: 114) mentioned that a Utah hunter removed from a female cougar, by Caesarean section, three fetuses each weighing 14 ounces a few days before normal birth.

Belle Benchley related (*in litt.*, 1952) that a cougar cub at the San Diego Zoo weighed a little over 9 pounds at 8 weeks of age. Two cubs described as 7-month-olds weighed 39 and 42 pounds, respectively.

Ernest Walker (*in litt.*, 1953) reported two kittens weighing 1.75 and 2.25 pounds, respectively, 7 days after birth. They each weighed 6 pounds at 6 weeks of age, but thereafter growth appeared subnormal.

Oscar Hansen of Provo, Utah, estimated that a cub he caught on 8 January 1947 weighed 8 pounds and was about 8 weeks of age. It weighed 15 pounds and measured 31 inches, total length, on 14 February 1947 at an estimated age of 13 weeks.

Frank Hibben (*in litt.*, 1952) gave the weight of a female, which he raised, as 19 pounds at about 90 days.

Jay Bruce (1922) stated that, in California, cougars weigh 35–50 pounds at 6 months and 65 pounds for females and 80 for males as yearlings. Similarly, Young and Goldman (*op. cit.*: 115) stated that cougars weigh 30 and 45 pounds for females and males, respectively, at 6 months and nearly double their weight at a year.

Completion of the curve was contingent upon the age and weight at maturity for the average male and female cougar. Weights of juvenile males and females within the same litters additionally aided in developing separate growth curves for the sexes (Table 1).

Young and Goldman (*op. cit.*: 112) state that female cougars first breed when 2 to 3 years of age. Three records at the National Zoological Park gave

initial breeding at the following ages: 2 years 6 months, 2 years 10 months, and 3 years. Whether these females were bred during their first estrus or came into breeding condition as early as wild animals is not known. Rabb (1959) cites a case of a captive cougar experiencing its first estrus when 2 years 5 months old. To aid in completion of the growth curve, we have assumed maturity for the female at 2.5 years.

Our observations have shown that some female cougars reach sexual as well as physical maturity at 80 pounds. Two females weighing less than this had newly formed corpora lutea or nearly mature Graafian follicles. The oldest female (teeth yellowed and worn, which Young and Goldman [p. 59] consider criteria of old age) examined was pregnant and yet weighed but slightly over 80 pounds. Another female weighed 80 pounds and was the mother of two 45-pound cubs. While one occasionally encounters a 90–100-pound female with an apparently virginal uterus, this is uncommon. We are, therefore, considering females 80 pounds and over as mature. The average of 50 weighed was 94 pounds (range, 80–132).

We have arbitrarily included weights of 125 pounds and over to derive an average weight for mature males. Thus, for 34 animals the average was 156 pounds (range, 125–192) which we are assuming is reached at 3 years. The two heaviest male weights of which we have knowledge, from Utah, were excluded. We heard of them only because of their unusual size, and inclusion would have biased the average unduly. One male, taken by Adria Ahlstrom in central Utah, weighed 204 pounds (Young and Goldman, *op. cit.*: 55). The other, which could well be the second largest on record, was killed by Frank Hibben and party in 1951, in the Book Cliffs of Grand County, Utah. The cougar weighed 265 pounds (Hibben, *in. litt.*, 1952). Seton (1929: 39) and Young and Goldman (*op. cit.*: 53) described the largest cougar reported to date. It was killed in Arizona and weighed 276 pounds with the "intestines removed."

Period when young are born.—Young and Goldman (*op. cit.*: 114) state that young may be born any month of the year. Bruce (*op. cit.*) reports that kittens are born in February, April, August or November, in his experiences as a hunter in California. Musgrave (1926) found kittens every month of the year in Arizona. Seton (*op. cit.*: 85) reported that young are born at any time, but usually in midwinter or early spring.

A monthly breakdown for 57 records of pregnant cougars obtained in this study is as follows: January, 10; February, 9; March, 4; April, 3; May, 5; June, 7; July, 11; August, 1; September, 1; October, 1; November, 2; and December, 3. These records suffice to show that cougars may have their young at any time of the year within the latitudinal range of this study (37–42° N). They do not, however, accurately reflect the relative monthly incidence of pregnancy, inasmuch as hunting effort and the take of cougars is not uniform throughout the year. To partially correct for this bias, the monthly incidence of pregnancy, expressed as percentages for 199 females

TABLE 2.—*"Mature" cougars examined for pregnancy by months in Utah and Nevada, 1946–58*

Month	No. Examined by Hunters		No. Examined by Writers		Total No. Examined	Pregnant	
	Total	Pregnant	Total	Pregnant		No.	Per cent
Jan.	18	1	38	3	56	4	7
Feb.	8	1	16	1	24	2	8
March	12	0	9	2	21	2	10
April	4	1	0	0	4	1	25
May	5	0	1	0	6	0	0
June	7	4	3	2	10	6	60
July	11	3	3	3	14	6	43
Aug.	9	1	1	0	10	1	10
Sept.	7	1	1	0	8	1	12
Oct.	3	1	0	0	3	1	33
Nov.	3	0	5	1	8	1	12
Dec.	11	0	24	2	35	2	6
Totals:	98	13	101	14	199	27	226
Mathematical monthly average:							19
Weighted monthly average:							14

examined from 1946–1958, is shown in Table 2. Only females believed no longer associated with their mother or litter mates were considered. This probably eliminates all animals less than a year of age and many of those between one and two years of age. Results from cougars examined by hunters and by us were markedly similar, so the two samples were combined. Thus, for the 199 females, pregnancy was grossly determinable in 27. May was the only month in which a pregnant animal was not found. However, one of the six examined that month displayed a swollen uterus and two recently formed corpora lutea which we interpreted as indicating early pregnancy or pseudopregnancy (assuming induced rather than spontaneous ovulation for the cougar, as is known for the domestic house cat—Asdell, 1946: 169).

Small samples in Table 2 have created considerable variability among the monthly pregnancy percentages. However, there is an indication of a higher rate during the warm months, particularly June and July, than during the cold ones. On this basis, the peak months for parturition could reasonably be expected sometime during the period of July–September. Pregnancy averages about 3 months (93 days based on 10 records: 96 days—record at National Zoological Park, Washington, D. C.; 86 and 90 days—Rabb, *op. cit.* [maximum and minimum possible periods were averaged]; 98 days—Allen, 1950; 95 days—Benchley, pers. comm.; 96 days—Fuller, 1832; 90, 92 and 93 days—Kenneth, 1947; 96 days—Allen, 1896). It is probably grossly detectable for about 10.5 weeks (see section on *Litter frequency* for derivation of this value). Thus, parturition for the average pregnant animal could be expected in half of this period or about 5 weeks from the time of examination.

Twenty-seven litters, however, inadequately reflect the monthly distribu-

tion of births. Therefore, the probable birth months were computed for 145 postnatal litters for which actual or estimated weights permitted age estimates (through reference to the growth curve previously developed). Actual weights for one or more individuals of 28 litters were obtained and length measurements, through the intermediate use of Fig. 2 (length over weight curve), permitted weight estimates for three additional litters. Ten more litters were either born to females in traps or were no more than a week or two of age when found, so their birth months were known. Thus, the birth month or weights were known for 41 litters and estimated weights were available for an additional 104 litters. Estimates were resorted to when cougar young were captured alive, when scales were unavailable, or when it was impractical to bring the carcasses in from the mountains. The estimates were made by us or by hunters who, by reason of having previously weighed cougars, were in a position to make fairly accurate estimates through mental comparisons.

July was the month of highest birth frequency for both categories and the period June–September contained the four highest months for one group and the three highest in the other (Table 3). Combined, the records indicate that 61 per cent of the computed births occurred during one-third of the year (June–September—Table 3 and Fig. 3). These data and the percentage of monthly pregnancies are in fair agreement in that the two months with the highest proportion of pregnancies (June and July) would necessarily contribute to the high birth frequency noted previously for June through September. This agreement, tenuous as it may be, supports results of litter aging from the growth curve.

Insofar as we are aware, the cougar is the only large wild animal in the Utah-Nevada area which may successfully breed every month of the year. Lack (1954: chap. 6) has pointed out that breeding in animals is so timed,

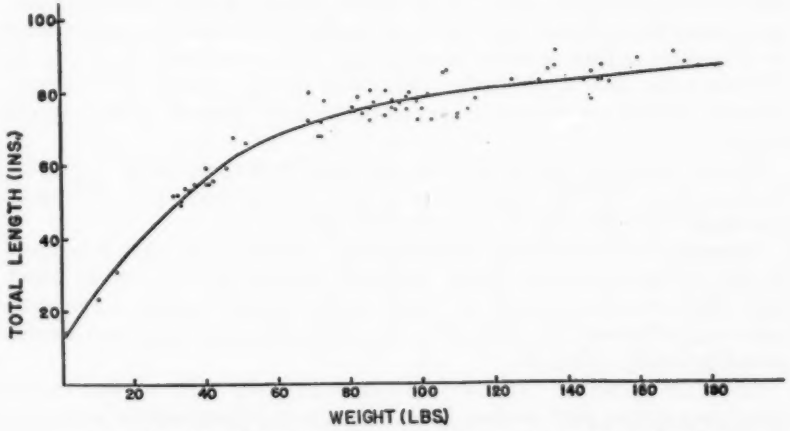

FIG. 2.—Total length over weight curve for cougars in Utah and Nevada.

TABLE 3.—*Summary of computed birth months for 145 cougar litters from Utah and Nevada*

Birth Month	Basis for Litter Aging		Total No.	Per cent
	Actual Weights or Known Birth Month No. Litters	Estimated Weights No. Litters		
Jan.	1	7	8	5
Feb.	1	3	4	3
March	2	2	4	3
April	4	8	12	8
May	3	5	8	5
June	6	14	20	14
July	8	22	30	21
Aug.	3	16	19	13
Sept.	5	14	19	13
Oct.	4	6	10	7
Nov.	3	4	7	5
Dec.	1	3	4	3
Totals:	41	104	145	100

through "survival of the fittest" and evolutionary processes, that young are produced at the most favorable season for their survival and growth. Critical temperatures and relative scarcity of high-quality foods are likely the most important restrictive forces opposing successful rearing of young during winter by most wild animals in temperate regions. Cougars are better able to cope with the food problem than most mammals. They are wider-ranging than most and are exceptionally efficient in capturing their favorite prey—deer—which is generally a much more stable year-long source of food than afforded by invertebrates, rodents, rabbits or vegetation. Temperatures at elevations of 6,000–7,500 feet, where the cougar is usually found during winter in Utah and Nevada, commonly reach 0°F or below. Almost without exception, cougars having litters during winter do so in shallow caves where the temperatures are less extreme than in more exposed sites. This is probably an important adaptation for survival of newly born young during critically cold periods, since the mother must, on occasions, leave them for hours at a time in order to hunt.

The fact that most cougar births in our region apparently occur during the warm months, however, suggests that food and temperature have influenced to a degree even the cougar's reproductive cycle.

Proportion of females with postnatal young.—Hunters were asked if "mature" females (those believed no longer with their mothers or litter mates) which they killed were accompanied by or were nursing young. The data and monthly percentages obtained for 299 females indicated that 41 per cent were accompanied by young (Table 4).

Period young remain with mothers.—It is generally believed that cougar young remain with their mothers for at least a year (Young and Goldman, *op. cit*: 116; Bruce, *op. cit.*). This belief is shared by the writers and many hunters.

A few cases of young in the "yearling" class still traveling with their mothers, for which actual or estimated weights were obtained, are as follows: (1) A 79-lb male; (2) a 94-lb male, a 51-lb female, and a 69-lb female, believed a single litter; (3) a 76-lb female; (4) two young estimated at 70–80 lb; (5) two young, one female caught and estimated at 70 lb; and (6) two young, one male caught and estimated at 75 lb.

Case 2 was of added interest because of the wide differences in weights of the three immature animals caught with an adult female and believed by the hunter to represent a single litter. Some might consider these young as being from at least two different litters. Strict adherence to the growth chart indicates respective ages of 61, 39 and 56 weeks for the cubs. It seems apparent that at least the two larger cubs were from the same litter. The implied age differential of 22 weeks between the male and smaller female theoretically gives adequate time for another litter. However, the maximum age of a second litter would be 9 weeks (22 weeks minus the gestation period of 13 weeks) and young of this age weigh around 10 pounds. It therefore seems likely that the smaller female was from the same litter, but less thrifty or inherently smaller. Size variation has been noted even among fetuses in the same litter.

In addition to the foregoing records, hunters have reported a number of yearling-size litters with the mothers. One instance involved a litter believed to be 2-year-olds. Three grown females traveling together were taken by

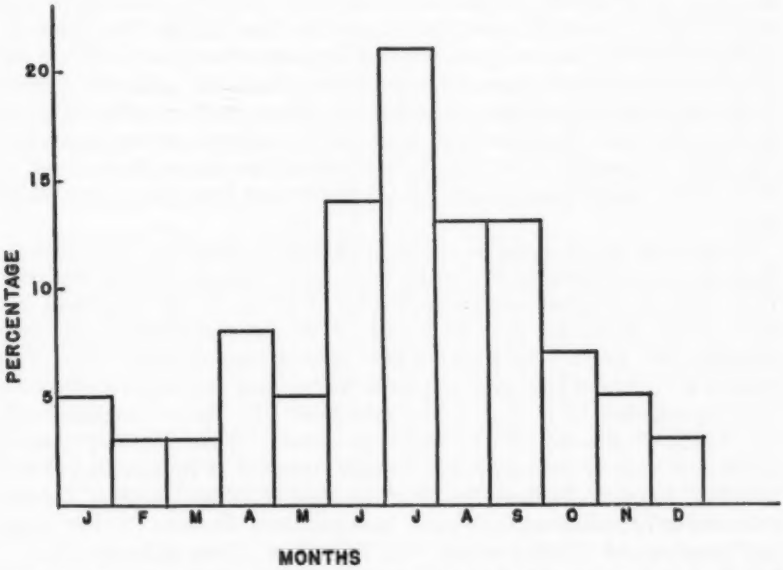

FIG. 3.—Computed percentage of births by months for 145 cougar litters in Utah and Nevada.

TABLE 4.—*Monthly proportion of "mature" female cougars accompanied by young in Utah and Nevada, 1946–1958*

Month	Total No.	"Mature" Females Accompanied by Young	
		No.	Per cent
Jan.	78	33	42
Feb.	48	24	50
March	29	10	34
April	3	2	67
May	8	4	50
June	15	4	27
July	15	4	27
Aug.	15	7	53
Sept.	9	1	11
Oct.	7	3	43
Nov.	17	11	53
Dec.	55	21	38
Total or Average	299	124	41*

* The mathematical and weighted averages were identical.

Austin Johnson in central Utah during January 1955. Johnson stated that, although they were essentially the same size, one was obviously older than the other two. Only one was weighed—a young one—and it registered 96 pounds, which is what one might expect for a 2-year or older animal. Uteri from the young females appeared virginal, whereas the uterus from the old female displayed three pigmented placental scars and was definitely maternal. In view of the probable age of the young females, there could be some question whether they were the old female's last litter. It has been our impression that pigmentation generally disappears from placental sites in less than a year. If this is true, it seems possible that the old female may have lost a more recent litter.

While many young appear to remain with their mothers for a year or more, there are some indications that many leave their mothers at about this time. Thus, we have weighed lone young females of 68, 72, 75 and 79 pounds and males of 70, 72, 87, 104 and 110 pounds. However, many litters apparently maintain their identity for a period after leaving their mothers. Thus, nine cases of two or more immature cougars in the yearling and long-yearling class traveling together have come to our attention: (1) Three "yearlings" estimated at 70–75 pounds; (2) two "yearlings"—male estimated at 70–75 pounds and female at 55–60 pounds; (3) two males estimated at 75 pounds; (4) two "yearling" females; (5) three "yearling" females; (6) three "yearling" females estimated at 70 pounds each; (7) two "nearly mature" females; (8) two "yearling" females; and (9) four which could have been a litter of 2-year-olds.

In the last case, two females weighing 84 and 103 pounds and two males of 113 and 115 pounds were killed in the same cave by Wallace Connolly, 30

January 1949, in Weber Canyon, Utah. Reproductive tracts from the females appeared virginal but unfortunately no ovarian sections were made to determine if ovulation was imminent. The uteri, however, were not swollen, so the females were probably not in estrus. We therefore suspect that these cougars were about 2-year-olds, representing a litter which had not yet split up.

In rare instances, juveniles of 60–65 pounds or less are found without their mothers, probably as a result of some misfortune to the parent. Thus, Fred Wintch of Manti, Utah, trapped two young emaciated cubs (weighing but 13 and 14 pounds) in March 1955. There were no tracks of a mature cougar in the vicinity. Total lengths of the cubs were 48 and 51 inches, respectively. According to the length-weight curve, cubs of this length should normally weigh at least 30 pounds, indicating they had been on their own for some time and were unable to adequately provide for themselves.

Ovulation rates.—Limited information on ovulation rates was derived from 12 sets of ovaries, each containing a set of large Graafian follicles (2–9 mm in diameter) and from corpora lutea counts for 21 females with pre- or early postpartum litters. Follicles which were counted in a set of ovaries were of uniform size and consequently believed of the same age or generation.

Litter sizes.—Information for 66 prepartum and 192 postpartum litters is listed in Table 5. The average size of the unborn litters was 3.3, compared to 3.0 for cubs up to 50 pounds and 2.2 for larger ones.

Mortality.—The average ovulation rate indicated by our small samples was 3.3, which was slightly less than the average prenatal litter of 3.4. Our samples are too small to reflect true rates for, unquestionably, not all ova shed result in viable embryos or fetuses. For example, 34 corpora and 29 fetuses in 9 gravid females for which complete corpora and fetal counts were made indicated that 85 per cent of the ova shed resulted in embryos or fetuses. A modal class of 4 for ova compared to 3 for prenatal and early postnatal litters is further indication that some ova fail to produce viable embryos or fetuses.

Sample variation is again apparent in the greater average size of litters in the 26–50-pound class as compared to the 0–25-pound class. By combining the two classes, an average litter of 3.0 is obtained which implies a 15 per cent mortality from the average litter of 3.4 during pregnancy. The implied mortality from pregnancy to cubs in the 51-pound-plus class is about 35 per cent, whereas the decline from the average of 3.0 cubs in the 0–50-pound class is 24 per cent. These percentages suggest that most of the postnatal mortality occurs among the oldest cubs, which is not necessarily true. Mortality from man is believed the most important decimating factor operating against cougar young. An entire litter of young cubs is much more apt to be taken by hunters than entire litters in the yearling class. Thus, in repeat litter observations, no additional records would be possible for the young litters, whereas a reduced litter size would be indicated for large cubs in which one or two had previously been taken. It is also possible that large cubs do not all leave their mother

TABLE 5.—*Ovulation rate and litter sizes for cougars in Utah and Nevada, 1930–1958*

Ova or Litter Class	Sets of Ovaries Containing			No. of Litters by Age or Size Class					
					Size of postnatal young, lb				
	Large Follicles	Corpora	All	Prenatal*	0–25	26–50	51+	Uncl.	All
1		1	1	1	2	3	6		12
2	2	5	7	9	23	18	20	7	77
3	3	3	6	28	26	35	9	14	112
4	6	12	18	20	11	11	2	3	47
5	1		1	7	1	1			9
6				1					1
No.:	12	21	33	66	63	68	37	24	258
Rate or Average:	3.5	3.2	3.3	3.4	2.8	3.1	2.2	2.8	2.9
					3.0				

* Four litters born prematurely to females in traps are included here. The single litter of six has previously been reported by Young and Goldman (1946: 114).

at the same time. If so, this could further explain the smaller litter size in the 51-pound-plus class.

Some mortality of young cubs is doubtless caused indirectly through loss of their mothers to hunting. Occasionally, nursing females are killed whose young are not found. Orphaned young, too small to follow their mother, doubtless succumb. We have previously reported the case of four one-third-grown cubs that had "tangled" with a porcupine during the 12-day interval between the death of their mother and their subsequent capture (Robinette *et al.*, 1959). Three of the cubs succumbed from porcupine quills a few days following capture and the same fate would doubtless have befallen them in the wild.

John Dalton of Parawan, Utah, killed a nursing female lion in late December 1952. After a search, he found her litter of 4-week-old kittens, one of which was dead. The cause of death was not determined.

Jack Butler of Springdale, Utah, told of having found young cougars on two different occasions, apparently killed by mature male cougars. One cub was about the size of a house cat. It was covered with saliva, but uneaten. In the other instance, Butler had been trailing a large male when he came onto a 25–30-pound cub, apparently killed by the male but uneaten. Young and Goldman (*op. cit.*: 138) cite an example of a male that apparently had killed and devoured part of a litter of young cubs after their mother had been killed.

Ted Cates of the U. S. Fish and Wildlife Service in Albuquerque, New Mexico, once observed a mature female cougar that had been killed by a larger cougar believed to have been a male. At the time (May 1951), Cates had been cougar hunting with Isom Newby and Arnold Bayne in southwestern New Mexico. The female, which they judged would weigh 90 to 100 pounds, had been badly clawed and chewed but not fed on, and had been killed within

the preceding two days. By backtracking 125 yards on the drag trail, they found where she had been killed.

Accidents account for the death of some mature cougars, especially when they are downing large prey. Two such instances have been reported (Gashwiler and Robinette, 1957).

Sex ratios.—We have sex records for relatively few cougar young. For 20 young examined in utero, or born prematurely to mothers in traps, 6 were males and 14 were females. Sex of 24 kittens born at the National Zoological Park was 12 males and 12 females, and one kitten reported by Allen (1950) was a male. Maloit (MS report, 1949) gives records of one male and one female fetus. Thus, the foregoing records for 47 fetuses or kittens at birth give 20 males and 27 females.

Our records of sex of postnatal young, still identified with litters, totaled 229 (112 males and 117 females for a ratio of 96:100).

Sex records for 649 "mature" cougars (those no longer identified with a litter) from Utah and Nevada, 1946–1958, gave a ratio of 92 males per 100 females. Young and Goldman (*op. cit.*) list sex records for 1,704 cougars, both juveniles and adults, from five western states, and similarly report a 92:100 ratio. We have no way of knowing, however, whether the sex ratio for the "mature" cougars accurately reflects the ratio in the wild population. Hunting could possibly be selective and give a biased ratio.

Litter frequency.—Young and Goldman (*op. cit.*: 114) state that cougars breed every 2 or 3 years and are 2 or 3 years of age when they begin breeding. Seton (*op. cit.*: 87) reports that the young "continue with the mother until they have learned to hunt for themselves, and this may mean 6 months, may mean well over a year, or even in some cases till they are 2 years old. In which case the mother breeds only every other year." The latter statement implies that breeding occurs more frequently in instances where the young remain with the mother for a year or less. Hunter (1921) states that females produce young every other year. Four consecutive intervals between litters for a female at the National Zoological Park were quite variable and substantially less than two years—12, 22, 15 and 8 months. There was no record, however, of how long the young remained with the mother, a factor which could possibly influence the frequency of breeding. Seton (*op. cit.*: 85) mentions a female at the Central Park Zoo that had seven litters in 16 years of captivity. If the animal was fertile throughout the entire period, the maximum average interval would be slightly over two years. It is possible, however, that the animal was not fertile during her first and last years of captivity, so the actual interval may have been less.

While our own information is somwhat indefinite, we suspect that many, perhaps the majority, of females in the wild have young every other year, but there is likewise some indication that some have young more frequently. Four of the 27 pregnant animals listed in Table 2 were also accompanied by young believed to have been yearlings. Two of the four were believed about 4 weeks

along in pregnancy (fetuses in each averaged 20 mm in crown-rump length). One of the females was accompanied by a "yearling" female estimated at 65–70 pounds. Figure 1 indicates a female of this weight would be 12 to 13 months of age. The computed breeding interval for the mother was, therefore, 14–15 months. The other pregnant female was accompanied by two males estimated at 75 pounds. These males were possibly no more than 11 months of age, so the computed breeding interval was about 13 months.

The remaining two pregnant females carried "haired out" fetuses, which probably were in their third month of development. Each female was accompanied by two younger cougars judged by the hunters to be "yearlings" on the basis of their tracks. Inasmuch as the "yearlings" were not caught, a more specific age estimate cannot be assigned, but the breeding interval for their mothers was likely close to a year.

We believe that the probable 12–15-month breeding interval exemplified by the foregoing cases is about minimum for wild cougars, in absence of litter mortality. Of the 199 females examined for pregnancy (Table 2), 70 were accompanied by young. Fifteen of the 70 were accompanied by cubs of yearling size and only four (cases listed above) of the 15 were pregnant. This small sample indicates that possibly a fourth of the females, whose cubs survive, have young as frequently as 12–15 months. The average interval determinable from the pregnancy records of Table 2 is one year or less, but we suspect that small monthly samples have unduly inflated the mathematical average monthly percentage of pregnant females. As mentioned earlier, pregnancy is probably grossly recognizable in the cougar for about 10.5 weeks. Asdell (1946: 168) lists the period of implantation in the domestic house cat as 12–15 days and gross recognition of pregnancy would likely not be possible until a few days thereafter, or possibly an elapsed period of 2.5 weeks. Deduction of 2.5 from a gestation period of 13 weeks leaves 10.5 weeks. Thus, if 19 per cent of all females are pregnant as a monthly year-long average, the implied interval between litters is 55 weeks (10.5 weeks/0.19). This is assuming that every female was of breeding age, whereas our examinations have indicated that about one-sixth of the "mature" females were virginal. Omission of non-sexually "mature" females would shorten the interval to something less than a year.

Another indication of litter frequency is afforded by records in Table 4. Forty-one per cent of the females were accompanied by young and, with no correction for those non-sexually mature and assuming that young remain with the mother for a year, the implied interval between litters is about 2 years 5 months. Omission of one-sixth of the females as sexually immature would reduce the interval to two years.

Continuance of a central tendency for litter births to occur during the June–September period would seem to indicate that the litter interval for the majority of females is a year or multiple thereof. Since we have already shown that relatively few appear to breed as frequently as one year, we suspect that the

interval for most females is two years. It therefore appears that the actual incidence of pregnancy among wild cougars would be less than the 19 per cent obtained in this study.

ACKNOWLEDGMENTS

We wish to thank the many hunters, federal and private, who provided records and collected female cougar reproductive tracts for this study. Particularly helpful were: Willis Butolph, George Nay, Walter Nelson, Adria Ahlstrom, Austin Johnson, Vernal Montgomery, Joseph Pearson, Albert Stewart, George Proctor, Phil Hurst, Edward Connolly, Jr., Russell Shores, and Lloyd Roberts. We are also indebted to Ernest P. Walker of the National Zoological Park in Washington, D. C., Grace Davall of the New York Zoological Park, Belle Benchley of the Zoological Society of San Diego, and to several others whose observations on captive animals have been quoted. Acknowledgment is due Forrest S. Romero for help in collecting information during one year of the study.

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GROWTH IN THE STELLER SEA LION

By Clifford H. Fiscus

Abstract: A discontinuity (growth line) is formed annually in dentin and cementum of the teeth of *Eumetopias jubata*. In a sample of 59 individuals, the oldest male showed 19 growth lines, the oldest female 22. Maximum body length and girth were, for males, 325 and 229 cm, for females, 269 and 168 cm. On the evidence of 12 skull measurements, the growth rate tends to level off at about 8 years in females and 10 years in males. The basioccipital–basisphenoid suture closes at about age 4 in both sexes. A sagittal crest is strongly developed in the male. Baculum length and weight tend to increase with age; the largest specimen (length 196 mm, weight 55 g) was from a 16-year-old. Of 28 bacula, one had been broken and was partly knit. Of 49 skulls, 6 lacked (from birth) 1 or 2 molariform teeth.

Skulls of the Steller sea lion, together with body length and girth measurements, were received by the Marine Mammal Biological Laboratory in November 1959 from Dr. Ole A. Mathisen, Fisheries Research Institute, University of Washington. The collection was made in June and July of 1958 at Chernabura Island (Shumagin group), Alaska (Mathisen, 1959) as part of a sea-lion investigation made through a contract with the Bureau of Commercial Fisheries.

The collection consisted of 49 skulls, of which 28 were taken from males and 21 from females; and the canine teeth from 5 other males and 5 other females. Date of collection and length and girth were missing from 10 of the specimens.

The purpose of this paper is to indicate the rate of growth, by sex, for certain skull characters, body length and girth, and baculum length and weight.

METHODS

Age-determination techniques used here were those originally developed for use on fur seals (*Callorhinus ursinus*) by Scheffer (1950). Further refinements in preparation of *Callorhinus* teeth for age-determination purposes have been described by Wilke *et al.* (1958). Essentially, the upper right canine tooth was removed, sectioned, and examined under a 3× lens. Annual growth was revealed in most teeth by cutting them in half longitudinally. Thin, longitudinal sections were taken from the center of teeth that were especially large or difficult to read, in order to improve growth-line visibility by permitting greater light penetration.

Structural growth of the sea-lion tooth is similar to that of the fur seal. The pulp chamber of the female tooth is well filled by 11 or 12 years and almost completely closed by 15 or 16 years. Closure is slower in the male. At 15 or 16 years, the pulp cavity of the male tooth is relatively larger than in a female tooth of the same age but is closed to a greater degree than in the female tooth of 11 or 12 years. The cementum layer contains annual growth lines which correspond to those of the dentin. Where the growth lines become obscure in the detin, the age can sometimes be determined on the cementum. The cementum layer in young teeth is usually not thick enough for age-determination techniques to reveal the annual lines clearly.

TABLE 1.—*Age and sex variation in body length and girth (cm) and 12 selected skull characters (mm)*

Age	N°	BL	G	CBL	BLH	PL	ZW	MW
Male:								
pup	1	–	–	201	–	–	–	–
1	1	178	114	249	226	109	131	114
3	2	208	143	307	274	145	159	136
5	1	272	178	361	329	171	196	183
7	1	262	178	343	312	168	194	173
8	2	310	229(1)	369	339	183	209	196
9	4	288	188	358	330	177	212	191
10	3	301(2)	188(2)	363	333	179	214	197
11	3	295	202	381	346	188	221	215
12	4	299	191	371	341	187	220	205
13	1	–	–	376	346	189	234	213
15	2	317(3)	210(3)	382	348	194	222	206
16	2	325	199	389	358	197	230	224
19	1	317	185	396	366	201	247	239
Female:								
2	1	180	117	252	225	111	135	114
9	2	237	160	303	277	144	162	141
10	2	234	152	309	281	151	169	151
11	2	237	154	300	274	137	163	144
12	3	243(2)	155(2)	303	278	147	161	144
13	2	243	171	307	282(1)	145	165	147
14	3	250	149	309	285(2)	150	167	150
15	1	244	147	320	294	152	168	153
16	1	252	157	315	285	149	171	149
17	1	264	168	315	285	150	177	146
18	2	245	155	306	278	145	171	155
19	1	236	155	–	–	–	–	–
20	1	269	163	322	297	154	171	156
22	1	241	165	–	–	–	–	–

Age	N°	IOW	LN	WN	H	UMS	MG	SW
Male:								
pup	1	60	32	24	–	55	4	67
1	1	51	31	27	102	69	8	73
3	2	51	47	33	110	84	17	90
5	1	56	67	40	123	100	24	111
7	1	52	51	40	124	97	22	104
8	2	55	57	48	143	101	24	121
9	4	56	54	41	138	102	24	121
10	3	61	57(2)	45(2)	144	103	25	124
11	3	56	59	43	151	109	28	125
12	4	57	59	43	147	101	21	125
13	1	56	58	46	159	108	27	130
15	2	57	59	45	153	111	23	121
16	2	62	65	47	165	111	29	143
19	1	60	62	49	160	104	22	136

TABLE 1.—continued

Age	N*	IOW	LN	WN	H	UMS	MG	SW
Female:								
2	1	46	38	–	96	67	8	66
9	2	47	43	31	107	89	21	83
10	2	49	47	33	112	91	21	91
11	2	41	47	29	107	86	21	78
12	3	44	46	31	108	90	21	84
13	2	49	50	31	109	91	25	85
14	3	45	45	34	109	93	23	86
15	1	45	47	31	116	94	23	88
16	1	47	48	35	111	–	–	86
17	1	44	46	36	109	94	21	77
18	2	48	43	31	109	88	19	82
19	1	–	–	–	–	–	–	–
20	1	43	46	32	116	96	20	80
22	1	–	–	–	–	–	–	–

* Number of specimens. Where more than one was available, the mean measurements are given. A number in parentheses ( ) indicates a different number of specimens.

The growth lines appear in the dentin as a series of alternating dark (winter growth) and light (summer growth) layers. A narrow layer or band is formed at birth. This is either translucent or opaque and is distinct from adjacent layers. It can be observed externally as a slight ridge encircling the tooth. Inasmuch as the ridges are visible extensions of the annuli, they are valuable as a check against internal layers in younger teeth. In older animals, the ridges become obscure and cannot be relied upon. One dark and one translucent layer represent one year of growth. Since the present specimens were collected in summer, a light band was being formed on the wall of the pulp chamber. Caniniform incisors (upper I^3) of four male specimens were also prepared. Growth lines on three pairs of incisors were found to correspond in number to those on the canines; growth lines on one pair were not distinct. No teeth of known-age sea lions were available for comparison but it is the author's opinion, based on experience with fur-seal teeth of known age, that the age-determination technique is accurate within plus-or-minus one year for most of the sea-lion specimens. Greater accuracy is attained in younger than in older specimens.

Eighteen abbreviations are used in Tables 1 to 3. Some of them refer to measurements, others to anatomical parts. The measurements are essentially those of Grinnell *et al.* (1937) and of Hall (1946). A key follows: *BL*, body length; *BLH*, basilar length of Hensel; *CBL*, condylobasal length (= entire length of skull in the sea lion); *G*, girth (behind fore flippers); *H*, height of skull at otic bullae; *I*, incisor; *IOW*, interorbital width (least distance across top of skull between orbits); *LN*, length of nasals; *M*, molar; *MG*, molar gap (diastema between sockets of upper P^4 and M^1); *MW*, mastoid width (exceeds

width of brain case in sea lions 3 years old or older); *N*, number of specimens; *P*, premolar; *PL*, palatilar length; *SW*, supraorbital width (between supraorbital processes); *UMS*, alveolar length of upper molar series; *WN*, width of nasals (greatest); *ZW*, zygomatic width.

RESULTS

Skull measurements are summarized by age and sex in Table 1. Where more than one individual of the same age and sex is represented, the mean is given.

Growth is rapid in the younger year-classes. The 1-year-old male approaches the size of the 2-year-old female in both body length and condylobasal length. In fact, sexual dimorphism is apparent in most skull characters. About 90 per

TABLE 2.—*Size of body and skull, according to age and as percentage of adult size*[*]

Age	BL, cm	% adult length	CBL, mm	% adult length	MW, mm	% adult width	H, mm	% adult height
Male:								
1	178	55.6	249	64.3	114	52.1	102	64.2
3	208	65.1	307	79.3	136	62.1	110	69.2
5	272	84.9	361	93.3	183	83.6	123	77.4
7	262	81.8	343	88.6	173	79.0	124	78.0
8	310	96.8	369	95.3	196	89.5	143	89.9
9	288	89.9	358	92.5	191	87.2	138	86.8
10	301	94.1	363	93.8	197	90.0	144	90.6
11	295	92.3	381	98.4	215	98.2	151	95.0
12	299	93.3	371	95.9	205	93.6	147	92.5
13	–	–	376	97.2	213	97.3	159	100.0
15	317	99.2	382	98.7	206	94.1	153	96.2
16	325	101.6	389	100.5	224	102.3	165	103.8
19	317	99.2	396	102.3	239	109.1	160	100.6
	(320)[*]		(387)[*]		(219)[*]		(159)[*]	
Female:								
2	180	72.2	252	80.3	114	75.0	96	85.7
9	237	95.2	303	96.5	141	92.8	107	95.5
10	234	93.6	309	98.4	151	99.3	112	100.0
11	237	95.1	300	95.5	144	94.7	107	95.5
12	243	97.2	303	96.5	144	94.7	108	96.4
13	243	97.2	307	97.8	147	96.7	109	97.3
14	250	100.1	309	98.4	150	98.7	109	97.3
15	244	97.7	320	101.9	153	100.7	116	103.6
16	252	100.8	315	100.3	149	98.0	111	99.1
17	264	105.8	315	100.3	146	96.1	109	97.3
18	245	98.3	306	97.5	155	102.0	109	97.3
19	236	94.6	–	–	–	–	–	–
20	269	107.9	322	102.5	156	102.6	116	103.6
22	241	96.7	–	–	–	–	–	–
	(250)[*]		(314)[*]		(152)[*]		(112)[*]	

[*] Adult measurements are the means for animals 15 years old or older.

cent of adult body length is achieved by age 8 to 10 (Table 2). Young animals of both sexes are poorly represented in the sample; therefore, the age limit for rapid growth is not exact. Measurements of condylobasal length, basilar length, palatilar length, zygomatic width, mastoid width, length of nasals, width of nasals, height of skull at otic bullae, and alveolar length of upper molar series show growth characteristics similar to body length.

Interorbital width differs between males and females, though it appears to change little with age.

Sexual dimorphism is least apparent in the measurement of molar gap; however, the growth rate is similar to that of the condylobasal length.

Height of the sagittal crest (not given in the table) increases as the animal grows older. Sagittal-crest height in males 7 years of age and older ranges from 7 to 37 mm. In females 9 years old and older, sagittal-crest height ranges from 2 to 7 mm, except for a 13-year-old skull on which no crest is evident.

The degree of suture closure between the basioccipital and basisphenoid bones was checked as an indicator of age. The suture is open in the male pup and 1-year-old male, and in the 2-year-old female. It is partly closed in the two 3-year-old males. In male skulls age 5 and older and in female skulls age 9 and older, it is closed.

Damaged teeth and alveoli occurred frequently and in about equal proportions among males and females. Except for the missing alveoli shown for various skulls in Table 3, dentition is otherwise normal.

TABLE 3.—*Missing and damaged alveoli in nine skulls*

Age	Skull No.	Sex	Missing alveolus	Remarks
9	57	♂	left M^1	congenital
			right M_1	congenital
11	21	♂	left M^1	congenital
15	53	♂	left M^1	congenital
16	1	♂	right P^2	congenital ?
19	40	♂	right M^1	acquired—early damage
10	47	♀	left I_2	acquired—early damage
11	48	♀	right M_2	congenital ?
14	14	♀	right M^4	congenital
16	29	♀	right and left M^1	congenital

Measurements and weights of 29 bacula (not given in the table) showed a rapid growth to age 7 to 9, increasing only slightly thereafter. Weight data are not completely reliable because methods of cleaning the bacula varied. The largest baculum (196 mm, weight 54.6 g) was from a 16-year-old. The only instance of damage was observed in the broken and partially knit baculum of a 19-year-old animal.

ACKNOWLEDGMENTS

The author is indebted to Ole A. Mathisen of the Fisheries Research Institute for making the material and data available; to Thomas P. O'Brien for assistance in preparing, measuring, and reading the age of the material; to Victor B. Scheffer for his assistance with the manuscript; and to other staff members of the Marine Mammal Biological Laboratory for critical comments.

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ABUNDANCE AND DISTRIBUTION OF THE STELLER SEA LION

BY KARL W. KENYON AND DALE W. RICE

ABSTRACT: Observations of the Steller sea lion, *Eumetopias jubata*, including hauling-out habits, seasonal movements, and aerial surveys in eastern Bering Sea from Bering Strait to and including the Aleutian Islands, are presented. Sea lions haul out during winter and spring, prior to the breeding season, in greater numbers in afternoon hours than in morning hours; few haul out during storms. The dearth of animals seen in the water during aerial surveys indicates that the great majority are hauled out during fair weather in the spring. The Pribilof Islands are the northernmost breeding grounds but a number of animals, probably adult and subadult males, migrate north in late summer and early fall. As many as 1,000 regularly reach St. Lawrence Island and a few reach Bering Strait. These animals move south again with the advance of ice in the fall but ice does not cause them to desert the Pribilof Islands. Certain hauling grounds within the breeding range are used seasonally. Aerial surveys of all Aleutian Islands and areas near the end of the Alaska Peninsula in 1959 and 1960 revealed 98 rookeries and hauling grounds with an estimated total of about 100,000 animals. The total world population of this species, based on the present report and on previously published data, is estimated to be about a quarter of a million animals.

The Steller sea lion, *Eumetopias jubata*, is an abundant pinniped, primarily in neritic waters, of the temperate North Pacific Ocean. Interest in this species has been expressed because of its possible predation on commercially valuable fishes. Because of the remote and rugged habitat occupied by this sea lion and because of the difficulty of collecting specimens at sea, much is still to

be learned of its habits, behavior, population dynamics, abundance and food habits. The Aleutian Islands appear to be the center of abundance of the species.

During studies of the sea otter (*Enhydra lutris*), the northern fur seal (*Callorhinus ursinus*), and the Pacific walrus (*Odobenus rosmarus divergens*), observations of the Steller sea lion were obtained. The study area includes the Aleutian Islands and eastern Bering Sea north to Bering Strait. Data were gathered on hauling-out habits, seasonal migration, and population and distribution. This paper presents results of the first complete aerial survey of the Aleutian Islands. Little information has previously been published concerning the seasonal occurrence of this species in northern Bering Sea.

METHODS

Studies of hauling-out habits were conducted by Kenyon at St. Makarius Point, Amchitka Island, during late winter and spring of 1959. A 50-power telescope and 7×50 binoculars were used to count sea lions on an offshore islet during varying weather conditions and at different times during the day.

Information on seasonal northward migration was obtained during pelagic sealing studies and aerial surveys and from other observers living in or visiting northern Bering Sea areas.

Aerial surveys were conducted with an R4D aircraft (a modified DC-3) equipped with two 565-liter auxiliary wing tanks, giving it a range of over 12 hours. A speed of 190 km per hour was maintained; the altitude was usually 75 m, but varied from 30 to 150 m depending on terrain and wind conditions. The flight course followed the entire shoreline of each island, from the beachline to about 100 m offshore, and circled all offshore rocks and reefs.

The location of each sea lion rookery or hauling ground was plotted on U. S. Coast and Geodetic Survey charts. As the survey was conducted prior to the breeding season, it was not possible to distinguish between rookeries and hauling grounds. The number of sea lions at each site was estimated visually by two or three observers. It was impossible to photograph each group of sea lions seen, though several groups were photographed. Counts made from the photographs closely verified the estimates that had been made during the flight (Plate 1). Although an error of from 6 to 10 per cent, similar to the results obtained by Pike and Maxwell (1958) and Bonnot and Ripley (1948), is inherent in this method, the order of magnitude of the estimates is reliable.

The western half of the Aleutian Chain, including all islands from Attu to Yunaska, was surveyed between 19 and 27 May 1959. The observers were David L. Spencer, Refuge Supervisor, Fish and Wildlife Service, and Kenyon; the pilots were Theron A. Smith, Aircraft Supervisor, Fish and Wildlife Service, and Jim Tilford, Bureau of Land Management.

The eastern Aleutians were surveyed on 3 and 4 March 1960. This flight included all islands from the Islands of Four Mountains to Unimak, and also

included several islands off the west end of the Alaska Peninsula: Amak, and adjacent Sea Lion Rock; the Sanak group; and Sandman Reefs. The observers were Kenyon and Rice; the pilots were Smith and Spencer.

In addition to those mentioned above, the following individuals kindly contributed unpublished information or assisted in field work: J. W. Brooks, F. H. Fay, C. H. Fiscus, M. L. Lantis, R. L. Rausch, D. F. Riley, W. E. Ripley, J. D. Wendler, and F. Wilke.

HAULING-OUT HABITS

Any census of sea lions is best obtained when the animals are on land. Knowledge of the hauling-out habits is helpful in indicating when the most successful population surveys may be expected and in evaluating surveys after they have been made.

Between mid-February and mid-May 1959, 31 observations of a sea-lion hauling ground used by 100 to 200 sea lions of both sexes and all ages were obtained. Counts of animals on land were made at various times of day and under different weather conditions. The following general conclusions are indicated from the data:

1. During stormy weather, especially when a heavy surf was running, sea lions tended to remain in the water. The majority remained in a compact

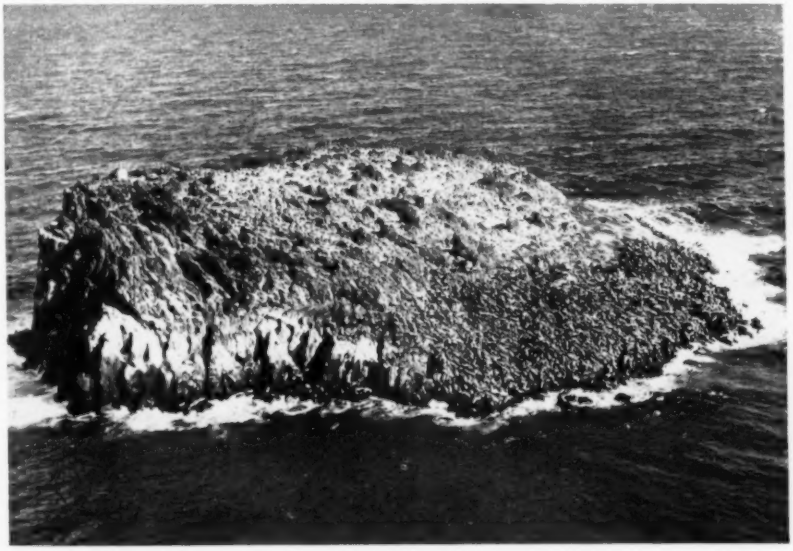

PLATE I

Sea Lion Rock, near Amak Island, Alaska. The field estimate made during a flight around this islet was 2,000 sea lions. A total of 1,905 was counted on this photograph. A few additional animals are hidden from view on the far side of the rock and others are beneath the water. 5 March 1960, KWK 60-15-3.

group in a favorite loafing area a few yards beyond the breakers near the eastern tip of the islet. Fourteen observations were made when storm conditions prevailed. During 11 of these, no sea lions were on land. In the other three instances, the numbers hauled out were 1, 2 and 36. Animals on land when a storm strikes may remain there for several hours but, as the storm progresses, they usually leave. Brooks (*in litt.*) noted, however, that on Lewis Island, where space above the beach is available, "many sea lions simply moved farther up on land during heavy weather."

2. During mild weather, especially if the wind is light and the sky clear, sea lions haul out in greatest numbers.

3. During daylight, more sea lions are on land in afternoon than in morning hours. The mean number on land during 10 morning observations was 45. The mean of 7 afternoon observations was 70. (Observations during stormy weather are excluded.) What effect tides and feeding rhythms may have on hauling-out habits was not ascertained.

MOVEMENTS

Observations in Alaska and in California indicate that the Steller sea lion undertakes seasonal movements, both latitudinal and local or longitudinal. Available data give a general indication of such movements but much is yet to be learned concerning the seasonal movements of different sex and age classes. Seasonal migration in the most northern part of the species' range appears to differ from that in extreme southern areas.

Latitudinal seasonal movement of the Steller sea lion is evident at the northern and southern extremities of the species' range. Bonnot (1951: 377) noted that "very few Steller bulls can be found on the California coast during winter." Bartholomew and Boolootian (1960) found no adult males in winter or spring in the California Channel Islands but found them there in June, indicating a northward movement of males during winter and spring. In the Bering Sea, northward movement takes place in the summer.

During low-altitude aerial surveys of St. Lawrence, St. Matthew, Hall, Nunivak, and the Walrus Islands of northern Bristol Bay in late February and early March 1960, no sea lions were seen. Surveys of the same areas again in late April revealed sea lions only on The Twins of the Walrus Islands where 400 were seen on 27 April (Wendler, *in litt.*). In late June of 1958, 66 sea lions, mostly subadults and a few adult males, were counted on The Twins (Fiscus, *in litt.*), perhaps indicating that many of those which arrive in the spring continue northward movement as the ice retreats.

Several hundred sea lions occupy St. Matthew and Hall islands in the summer. They apparently do not arrive, however, until after mid-July. Hanna (1920) spent 8 to 14 July 1916 there and did not record the species. On 9 August 1957, Klein (1959 and *in litt.*) saw 350 sea lions hauled out about 2 miles south of Elephant Rock on Hall Island. No pups were present; all animals were adult or subadult. Three carcasses found on beaches of St. Matthew

were males. On 2 August 1960, over 100 sea lions were hauled out at the base of Cape Upright, St. Matthew Island (Wilke and Fiscus, *in litt.*).

At St. Lawrence Island, sea lions occur regularly but in variable numbers in summer and early fall. Fay (*in litt.*) gives the following information from field notes taken 1953 through the fall of 1959: "The principal places occupied are the offshore rocks at Southwest Cape ("Pikaluk"), 63° 18′ N, 171° 27′ W, and the southernmost of the Punuk Islands, 63° 04′ N, 168° 50′ W." None has been recorded prior to 27 June. From late June until late September, individuals and groups of five or six animals were seen but their presence during this period varied in different years. On 25 September 1953, about 1,000 were on the rocks and beach at Southwest Cape and 3 or 4 days later 200 were on south Punuk Island. The natives say that the greatest number arrives in September and that they depart in November when the ice comes. The animals are molting when they haul out at St. Lawrence. Each year the natives take about 20 animals. No females have been taken and it is presumed that all sea lions seen there were males.

In the course of anthropological studies on Nunivak, Lantis questioned resident Eskimos in detail about marine mammals. Of the sea lion, she says (*in litt.*), ". . . an old Nunivaker, a man who had been an oustanding hunter, told me in 1940 that they were found on the west side of the island. They were harpooned in spring and summer, especially in summer, in open water. . . . Although not numerous they were known to all hunters." Spencer, who has conducted aerial surveys of Nunivak, says (*in litt.*), "I have no record of sea lions on Nunivak Island. Our surveys have all been conducted in winter or June and early July."

Natives of Little Diomede told Kenyon that a few individual sea lions are seen, especially near Fairway Rock and the south end of Big Diomede, in late summer and early fall; but their occurrence is not regular and they leave as soon as the ice comes. Rarely is an animal taken.

It may be assumed that the sea lions which migrate to the northern Bering Sea in summer move north from as far south as the Aleutian Islands. In June and July of 1955, during pelagic fur-seal studies between Unimak Pass and the Pribilof Islands, Kenyon saw several individual adult male sea lions, far at sea, swimming steadily in a northerly direction. During a pelagic sealing cruise from Amak Island to the Pribilofs on 11 and 12 July 1960, Fiscus and Kenyon saw a total of 12 sea lions well away from land. A group of eight adult and subadult males were 70 nautical miles north of Unimak Island and two others were 85 miles east of St. George. Tagging programs now being undertaken by both the Alaska Department of Fish and Game and the U. S. Fish and Wildlife Service should eventually contribute much information on the movements of sea lions.

Within its latitudinal range of year-round abundance, from the Pribilof Islands to central California, local seasonal or longitudinal movements of variable degree occur. In general, it appears that breeding grounds are also used

TABLE 1.—*Steller sea lion populations in the Aleutian Islands*

Reference number	Location of hauling ground or rookery	Estimated number of sea lions
	Near Islands:	
1	Attu (Cape Wrangell)	5,000
2	" (Chirikof Point)	10
3	Agattu (Gillan Point)	3,000
4	" (Otkriti Bay)	100
5	" (Cape Sabak)	3,300
6	Alaid (west end)	1,500
7	Shemya (rocks off north shore)	2,500
	Rat Islands:	
8	Buldir (south shore)	2,500
9	Kiska (Cape St. Stephen)	1,000
10	" (Vega Point)	400
11	Tanadak	50
12	Rat Island (eastern point)	750
13	Amchitka (Bird Rock)	50
14	" (islet off Chitka Point)	50
15	" (Ivakin Point)	300
16	" (East Cape)	200
17	" (St. Makarius Islet)	50
18	" (southwest islets and rocks)	600
19	Semisopochnoi (rocks off SW shore)	500
20	" (Pochnoi Point)	2,000
	Delarof Islands:	
21	Amatignak (Nitrof Point)	200
22	" (Knob Point)	50
23	Unalga (Dinkum Rocks)	350
24	Ulak (south point)	1,500
25	Gareloi (south shore)	2,500
26	Skagul (rocks off south point)	500
27	Tag Island	400
28	Ugidak	400
29	Gramp Rock	700
	Andreanof Islands:	
30	Tanaga (Sasmik Cape)	75
31	" (north side of Cape Sajaka)	100
32	Adak (Argonne Point)	1,000
33	" (Hook Point)	1,500
34	" (Cape Yakak)	800
35	" (rock off Cape Moffett)	50
36	Little Tanaga (Tana Point)	450
37	Great Sitkin (Swallow Head)	650
38	Anagaksik	700
39	Igitkin (southwest point)	700
40	Kasatochi (north point)	200
41	Ikiginak	500
42	Atka (North Cape)	550
43	" (Cape Korovin)	100
44	Salt Island	100
45	Sagchudak	1,200

TABLE 1 (contd.).—*Steller sea lion populations in the Aleutian Islands*

Reference number	Location of hauling ground or rookery	Estimated number of sea lions
46	Amtagis	800
47	Amlia (Cape Misty)	750
48	" (rocks in Sviechnikof Harbor)	800
49	" (Agligadak Point)	700
50	Sagigik	100
51	Tanadak	20
52	Agligadak	250
53	Seguam (southwest point)	150
54	" (Lava Point)	150
55	" (Wharf Point)	100
56	" (Saddle Ridge Point)	25
57	Amukta (High Rock and adjacent rocks)	600
58	" (Amukta Point)	150
59	Chagulak (Chagulak Point)	100
60	Yunaska (east shore)	800
	Islands of Four Mountains:	
61	Carlisle Island (northwest point)	100
62	Chuginadak (Concord Point)	700
63	Uliaga (northwest shore)	500
64	Kagamil (north point)	75
	Fox Islands:	
65	Adugak	1,000
66	Ogchul	2,000
67	Umnak (Cape Aslik)	450
68	" (Cape Idak)	600
69	Unalaska (Point Tebenkof)	200
70	" (Cape Starichkof)	100
71	" (Spray Cape)	200
72	" (Cape Izigan)	150
73	" (Whalebone Cape)	1,000
74	" (Cape Kalekta)	10
75	Bogoslof	1,000
76	Fire Island	100
77	Akutan (Lava Point)	6,520
78	" (between Lava Bight and Reef Bight)	200
79	" (Flat Bight)	2,000
80	" (Cape Morgan)	7,000
81	Akun (Akun Head)	2,000
82	" (Billing's Head)	100
83	Tanginak	600
84	Tigalda (rock off west end)	10
85	" (rock off northeast end)	750
86	Ugamak (west end)	400
87	" (southeast point)	1,500
88	" (northeast point)	10,000
89	" (north point)	1,000
90	" (northwest point)	500
91	Aiktak	600
92	Round Island	6,000

TABLE 1 (contd.).—*Steller sea lion populations in the Aleutian Islands*

Reference number	Location of hauling ground or rookery	Estimated number of sea lions
93	Unimak (Oksenof Point)	4,000
94	" (Cape Sarichef)	200
	Amak group:	
95	Amak	350
96	Sea Lion Rock	2,000
	Sanak group:	
97	South Rock	1,000
	Sandman Reefs:	
98	Clubbing Rocks	200
	Total on land	99,745
	Total in water	460
	Grand total	100,205

as hauling grounds at all seasons but some hauling grounds are used only at certain seasons. During the breeding season, nonbreeders may occupy areas not used during winter months. An example is a small islet in Kirilof Bay at Amchitka Island. Several hundred nonbreeding adult and subadult animals habitually haul out on this islet during summer and early fall. In late fall it is deserted and during winter and early spring none has been seen there. A reversal of seasonal occupancy is observed at Otter Island of the Pribilofs. During summer months only 75 to 160 adult and subadult males are scattered along its rocky beaches but local residents say that during winter months large numbers regularly haul out and occupy an area of gently sloping land away from the beach on the north side of the island.

Although the Steller sea lion is not an ice animal and deserts its northernmost hauling grounds as the ice advances in late fall, ice does not cause sea lions to desert the Pribilof Islands. On 9 April 1955, when pack ice surrounded the Pribilofs, Wilke and Kenyon saw approximately 1,000 sea lions hauled out on Otter Island and several others rested on ice floes. The few animals that could be identified as to sex were males, perhaps indicating a southward winter movement of adult females in this northernmost breeding area.

AERIAL SURVEYS

From the above discussion it is evident that the winter-spring aerial surveys of the Aleutian Islands took place during the period when a maximum number of sea lions might be expected in that area. Since some areas were surveyed during morning hours, it is indicated that the total estimates of animals seen on land are lower than they would have been if all surveys could have been conducted during afternoon hours. All surveys were conducted during fair weather. Unknown numbers of animals are in the water at all times and are

not seen. On the basis of the few (460) seen in the water at distances from hauling-out areas, however, it may be assumed that a large majority were hauled out. A complete list of the locations and estimated numbers of sea lions seen are shown in Table 1 and the geographical location of each group is indicated on Fig. 1. It is interesting to note that aerial surveys of sea lions conducted by the Fisheries Research Institute (Mathisen, 1959), which made extensive use of aerial photography, correspond closely with the estimates we obtained in areas where the surveys overlapped.

DISCUSSION

The breeding range of the Steller sea lion extends from Santa Rosa Island off southern California (34° N; Bonnot, 1929) to the Pribilof Islands (57° 15′ N). In summer and fall a northward movement of animals, apparently all males, as far as Bering Strait (65° 45′ N) occurs. An individual (identity not verified) recorded at Herschel Island, Yukon Territory (69° N; McEwen, 1954) was a wanderer far north and east of the regular summer range.

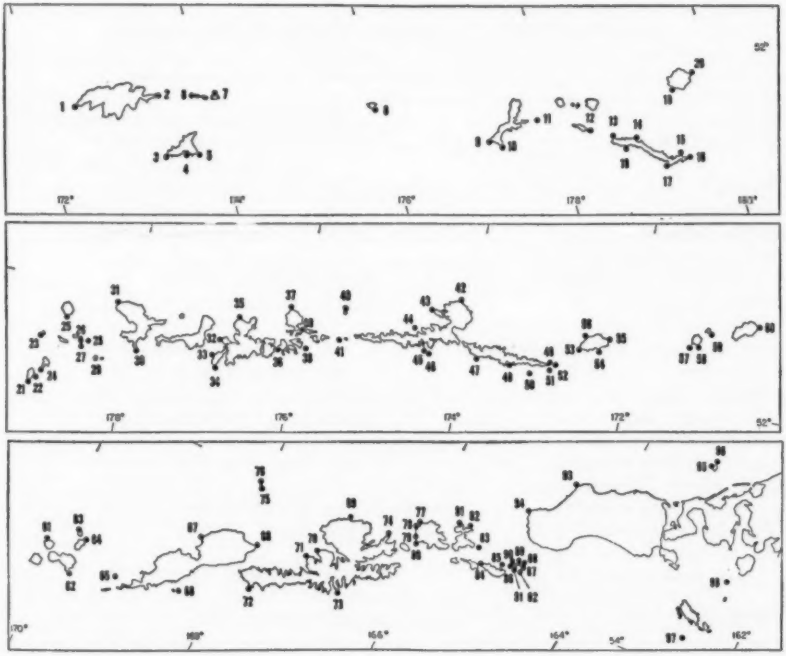

FIG. 1.—Map of the Aleutian Islands, showing location of Steller sea lion rookeries and hauling grounds in use at the time of the surveys. UPPER: Near Islands to Rat Islands; MIDDLE: Delarof Islands to Yunaska; LOWER: Islands of Four Mountains to Alaska Peninsula. For key, see Table 1.

It does not breed on the Commander Islands, but from October to April, "sea lions, almost exclusively males" are found there. At the beginning of April they probably migrate to the east coast of Kamchatka (Barabash-Nikiforov, 1938). The species has also been recorded from Hokkaido, northern Hondo, and Korea (Ellerman and Morrison-Scott, 1951; Okada, 1938). Nishiwaki and Nagasaki (1960) estimate that 1,000 to 3,000 Steller sea lions migrate to the coastal waters of Japan. Aside from a report of about 35 sea lions on Todo-iwa on the Hidaka coast of Hokkaido, which were attacked with aircraft at the request of local fishermen on 26 March 1959 (American Embassy, Tokyo, Foreign Service Dispatch No. 1135, 3 April 1959), no recent specific information on sea lions in this area seems to have been published. During fur-seal studies in waters near Hokkaido in the winter, spring, and summer of 1949, 1950 and 1952, Wilke and Kenyon saw no Steller sea lions.

A résumé of published information concerning population estimates of Steller sea lions throughout their range is presented in Table 2. Most of the authorities cited also give precise locations for each rookery or hauling ground within their

TABLE 2.—*Summary of population estimates of Steller sea lions*

Area	Number	Authority
Southern California	50	Bartholomew and Boolootian (1960)
Northern California	6,002	California Department of Fish & Game (*in litt.*, 1960)*
Oregon	650– 1,000	Rice, Field notes, 1960
Washington	400– 500	Kenyon and Scheffer (1959)
British Columbia	11,000– 12,000	Pike and Maxwell (1958)
Southeastern Alaska to the Shumagin Islands	76,027	Mathisen (1959)
Aleutian Islands	100,205	Present report
Pribilof Islands:		
St. Paul Island and Sea Lion Rock	300	Kenyon, field notes, 1960
Otter Island	160	Kenyon, field notes, 1960
Walrus Island	4,000– 5,000	Kenyon, field notes, 1960
St. George Island	1,200	Riley, field notes, 1960
Kamchatka (9 rookeries and hauling grounds)	No data	Rass *et al.* (1955)
Kurile Islands (23 rookeries and hauling grounds)	15,000– 17,000	Klumov (1957)
Okhotsk Sea (Svyatov Iony)	5,000– 6,000	Nikulin (1937)
Okhotsk Sea (9 other rookeries and hauling grounds)	No data	Rass *et al.* (1955)
Total	219,914–225,444	

* Ripley gives the following information: "We have made aerial estimates of sea lions on rookeries of California for the years 1958 and 1960. Although we do not have the species delineated in the aerial photos, it can be considered that the population north of Point Conception is nearly all Stellers. Therefore, based on this assumption, the counts for 1958 would be 7,116 and for 1960 would be 6,002. Our estimates this year did not include Southern California or the California islands."

respective areas. Therefore, it appears that a large majority of the rookeries and hauling grounds used by this species have been recorded. Omitted from this summary are the several hauling grounds in the Bering Sea north of the Pribilof Islands; census figures from rookeries and hauling grounds only within the year-round range of the species are used to avoid possible duplication.

The total estimates range from 220,000 to 225,000. There are no data available for nine rookeries and hauling grounds on the east coast of Kamchatka, and nine in the Okhotsk Sea and on Sakhalin, as reported by Rass *et al.* (1955). In the Kurile Islands, the mean number of animals hauled out on each rookery or hauling ground is about 700. A tentative guess of 13,000 animals on the 18 sites for which no counts are available may thus be made, giving a total estimate of about 233,000 to 238,000 on recorded rookeries and hauling grounds. It is, of course, impossible to estimate the number of animals missed in the surveys because they were in the water. It is the opinion of the authors that the total Steller sea-lion population numbers between 240,000 and 300,000.

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Received 14 November 1960.

THE SMALL MAMMALS OF THE WICHITA MOUNTAINS WILDLIFE REFUGE, OKLAHOMA

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ABSTRACT: Compilation of all available records reveals that a total of 34 species of mammals, exclusive of carnivores and ungulates, are found on the Refuge. Of these, ten are considered to be componeats of the eastern Austroriparian fauna, twelve are true plains species, six are derived from the southern Rocky Mountain fauna, two are cosmopolitan, one is subtropical, and three are introduced exotics.

In a recent paper (1959), the writers outlined the history of the Wichita Mountains Wildlife Refuge and reviewed the status of the carnivores and ungulates of the area. Knowledge of many unpublished records of the refuge's small mammals prompts us to review the rest of the fauna of this physiographically distinct region. Since the geology and ecology were summarized in our previous paper, it is sufficient here to state that the refuge contains four main ecological types: rocky mountains of weathered granite, boulder ridges, gravelly plains with soils of varying depths, and watercourses with narrow floodplains of fairly deep soil. Administration of the area is under the Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Department of the Interior.

The semipopular account of the refuge and its fauna by Sturgis (1939) and the specimens recorded by Blair (1939*b*) constitute the only comprehensive lists of mammals on record for the area. These authors noted the occurrence of 16 and 17 species, respectively, of small mammals. In this report the number recorded, exclusive of carnivores and ungulates, is 34.

We are indebted to Miss Viola S. Schantz for compiling a list of specimens in the U. S. National Museum (Biological Survey Collection), and to the late Dr. A. O. Weese for a list of specimens in the University of Oklahoma Museum. Additional specimens were from the collection at the Refuge Headquarters, and from the Oklahoma State University Museum. Unpublished records at Refuge Headquarters were field notes of O. J. Murie, C. H. Rouse and F. B. McMurry, and an extensive report by Vernon Bailey. Responsibility for assigning the specimens to their proper taxonomic categories is assumed

by the authors, and is based on personal study as well as opinions of latest revisers. In most cases our classification follows that of Hall and Kelson (1958). A collection of owl pellets secured on the refuge by McMurry has been analyzed by the senior author and his students and the results are incorporated in this report.

Blair and Hubbell (1938) designated the Wichita Mountains a biotic district. They recognized the mountains as surrounded by and permeated with the flora and fauna of the mixed-grass plains, and presumably based the district on physiographic rather than faunistic distinctions. Of the small mammals, Blair (1939*b*) noted that only the harvest mouse, *Reithrodontomys fulvescens intermedius*, was in Oklahoma confined to the district. Later revisions invalidate this distinctive claim. Because of their limited area and the lack of uniqueness in their biotic community, we are inclined to disregard the Wichita Mountains as a recognizable biotic entity. The main factors affecting the mammalian fauna are the rocky nature of the terrain, which provides habitat for saxicolous species that is unavailable in adjoining areas, and the total climate, which is amenable to forest growth, thus providing a fingerlike westward extension of the eastern Austroriparian forest. Because the mountains are within the Great Plains, yet fairly close to the Rocky Mountains, they form a meeting-place for faunas of several contrasting areas. For the 34 species reported herein, the following affinities are discernible: Austroriparian 10, Great Plains 12, southern Rocky Mountains 6, cosmopolitan 2, subtropical 1, exotic 3. Of the carnivores and ungulates, whose affinities were not discussed in our previous paper, most have ranges too cosmopolitan to be significant. Only the bison and pronghorn would represent the Great Plains, and the elk the southern Rocky Mountains.

ANNOTATED LIST OF SPECIES

Didelphis marsupialis virginiana Kerr.—Opossums are common on the refuge. During years when trapping was permitted, as many as 324 were taken in a single year. Distribution, Austroriparian.

Blarina brevicauda carolinensis Elliot.—Five specimens of *Blarina* are extant. Most of them came from the top of Elk Mountain, which has a tabletop with considerable soil depth. One came from the Narrows of West Cache Creek near the southern boundary. Numerous remains from barn owl pellets indicate that the species is abundant. The relationships of Oklahoma shrews of this genus were recently reviewed by Jones and Glass (1960), who concluded that all specimens, including those from the Wichita Mountains, are referable to *carolinensis*. Wichita specimens extend the known range for the species westward some 50 miles from the Arbuckle Mountains. Distribution, Austroriparian.

Cryptotis parva parva Say.—Two specimens are available. One in the Oklahoma State University Collection was from a grassy area bordering West Cache Creek in Boulder Canyon. The species appears commonly in owl pellets. Distribution, Austroriparian.

Notiosorex crawfordi crawfordi (Coues).—Two specimens are known from the refuge. A female was reported by Handley (1956). The rostrum of a second specimen was recovered from a barn owl pellet collected in 1942. No specimens are known for adjoining areas, and there are only three others for the state; from Cimarron, Woodward, and Pushmataha Counties. The first two are in the Oklahoma State University Collection, the third is at the University of Texas. Distribution, southern Rocky Mountain.

Scalopus aquaticus intermedius (Elliot).—According to Bailey, moles occur throughout the refuge wherever suitably mellow soil occurs. Rouse collected two specimens in 1939, and Glass secured one at French Lake in 1957. They have been detected in the diet of coyotes, and are occasionally to be found in owl pellets. Distribution, Austroriparian.

Myotis velifer incautus (J. A. Allen).—The biological Survey Collection contains a series of 15 of these bats, and the authors have taken one at Penick Tunnel. A breeding colony is known from near the western boundary of the refuge, near Mountain Park. Presumably these bats live in rooms among the boulder piles characteristic of these mountains. Distribution, southern Rocky Mountain.

Myotis subulatus melanorhinus (Merriam).—A single specimen, taken 16 July 1956, is the only one known for the refuge. This is the easternmost Oklahoman record for the species. Numerous specimens have been taken in other parts of the Wichita Mountains, where they live in cavernous places within piles of boulders. Distribution, southern Rocky Mountain.

Pipistrellus hesperus oklahomae Glass and Morse.—In Oklahoma this species has been collected only in the Wichita Mountains, but it is also known from Garza County, Texas, on the eastern edge of the High Plains. The Oklahoma State University Collection contains two specimens from the refuge. One is a mummy discovered by Halloran in the chapel tower at the Easter Pageant grounds. The other, a juvenile, was shot by Glass at the south boundary fence where West Cache Creek leaves the refuge. Numerous individuals of this species were seen flying over Lost Lake in late March 1955. They emerged well before dark and could easily be identified by their slow fluttering flight. The Wichita Mountains seem to be the only region in North America occupied jointly by both species of *Pipistrellus*. Distribution, southern Rocky Mountain.

Pipistrellus subflavus subflavus (Cuvier).—A male and female of this species were taken in the Penick Tunnel by O. J. Murie in 1935. None has been taken since. However, the species occurs sparingly to the north and west of the refuge in limestone and gypsum caves. Evidently the Arbuckle and Wichita Mountains provide a route for this species to extend its range into suitable habitats within the plains. Distribution, Austroriparian.

Plecotus townsendi pallescens (Miller).—There are three specimens of this species in the Biological Survey Collection, and Glass collected one in the Penick Tunnel in July 1956. Another one was seen there, but not collected, in March 1955. The species is found throughout the Southwest wherever caves occur. Distribution, southern Rocky Mountain.

Lasiurus borealis borealis (Miller).—Two bats of this species are in the Biological Survey Collection and one is in the Oklahoma State University Museum. Judging by numerous records from surrounding areas, the species is not rare during summer. Distribution, cosmopolitan.

Lasiurus cinereus cinereus (Beauvois).—A single specimen of this species is in the Biological Survey Collection. The species is found throughout Oklahoma in summer. Distribution, cosmopolitan.

Dasypus novemcinctus mexicanus Peters.— In Kansas and most of Oklahoma the armadillo is not at all common. Along the Red River Valley, however, it is well established. It may be expected to increase in numbers in and around the refuge. In 1949, former manager Ernest J. Greenwalt informed the senior author that armadillos were on the increase. In 1939, McMurry reported one from 5 miles south of the Indiahoma entrance and noted that two others had been seen there during the year. Halloran saw one road kill northeast of the refuge in June 1956, and another one a mile west of Indiahoma in July 1958. Manager Julian A. Howard encountered one in his garden in July 1958. McMurry's specimen is in the Biological Survey Collection and was recorded by Gardner (1948) as having been taken on the refuge. Actually the site has never been a part of the refuge, and is now a part of the western sector of the Fort Sill Military Reservation. Distribution, subtropical.

Lepus californicus melanotis Mearns.—The jack rabbit is usually common in grass meadows, as indicated by numerous road kills in the public section of the refuge. *Lepus*

remains occur with great frequency in pellets of the great horned owl. Nelson (1909) mentioned one from Mount Scott, there is one in the University of Oklahoma Museum, and McMurry deposited two in the Biological Survey Collection taken in 1939 and 1940. Distribution, Great Plains.

Sylvilagus floridanus llanensis Blair.—Prior to Blair's (1938) description of the race *llanensis*, all cottontails from the Wichita Mountains were referred to the form *alacer*. This accounts for the appearance of both names in the literature. Blair assigned specimens from Mount Scott at the eastern end of the mountain chain to *llanensis*, indicating that it is the race found throughout the refuge. Hall and Kelson (*op. cit.*) indicate that the zone of intergradation with *alacer* lies just to the east of these mountains, and it is therefore quite possible that some specimens from the area may be intergrades. Under these circumstances, we prefer to call all specimens from the refuge *llanensis*. Cottontails are very common at lower levels in the postoak-blackjack forests and along the streams where there is good grass cover. Road kills and owl-pellet recoveries attest to its abundance. Distribution, Great Plains.

Sylvilagus auduboni neomexicanus Nelson.—Two cottontails collected by McMurry in 1939–40 and sent to the Biological Survey Collection are of this species. The University of Oklahoma Museum also contains a specimen. The presence of wide expanses of grassland doubtless accounts for the occurrence of this species, which here reaches the eastern limit of its range. Distribution, Great Plains.

Cynomys ludovicianus ludovicianus (Ord).—Prairie dogs have occurred in several parts of the refuge in open grassland (Osborn and Allen, 1949). In 1946 there were five active colonies, but in 1960 only one remains. This thriving group has attracted thousands of visitors each year, and is referred to as the "official dogtown." It is located along the scenic highway on Turkey Creek about 1.5 miles east of Refuge Headquarters. If the natural increase of this town were not periodically checked, it would spread rapidly into adjacent grasslands. Peripheral control restricts the colony to less than 100 acres. The other populations on the refuge have been eliminated to provide for the proper maintenance of the bison and longhorn herds. Young dogs in official dogtown are first seen between the first and third weeks of April. Numerous requests for prairie dogs for zoos and research laboratories have been filled with animals live-trapped from this colony. Distribution, Great Plains.

Citellas tridecemlineatus texensis (Merriam).—The thirteen-lined ground squirrel is an uncommon occupant of the intermontane meadows. Bailey and Murie both noted the occurrence of the species, but apparently only two specimens have been collected. One is in the Biological Survey Collection, and one is in the Refuge Collection. Distribution, Great Plains.

Citellus spilosoma marginatus (Bailey).—The spotted ground squirrel occurs in intermontane meadows. Three specimens in the Biological Survey Collection, taken in 1939, constitute the only records. Two of these came from a now-defunct prairie-dog town in the north part of the big game pasture. The third came from a meadow east of Comanche Lake. These specimens constitute the easternmost record for the species in the state. Elsewhere in Oklahoma, they are usually to be found in sandy soil or in dunes. Distribution, Great Plains.

Sciurus niger rufiventer Baird.—Fox squirrels are very abundant in all wooded areas of the refuge. The University of Oklahoma Museum contains one specimen, there are 12 in the Biological Survey Collection, and four in the Refuge Collection. All specimens of fox squirrel from Oklahoma should be referred to the race *rufiventer*, as the Grand Prairie south of the Red River seems to be the natural barrier between it and the races *ludovicianus* and *limitis* to the south. Distribution, Austroriparian.

Glaucomys volans saturatus (Linnaeus).—The 1933 U. S. Forest Service Fish and Game Report states that a pair of flying squirrels were obtained from a building on the refuge. In 1935, Bailey referred to the species but stated that he had not seen it personally. Evi-

dently he was referring to the 1933 report, as was Sturgis (1939). No other records of flying squirrels on the refuge are known. Their distribution would be restricted to the stands of larger trees along the creeks. Distribution, Austroriparian.

Perognathus hispidus spilotus Merriam.—Two specimens of this species in the Biological Survey Collection are the only ones available, but its abundance in barn-owl pellets indicates that is is one of the most numerous small mammals on the refuge. Distribution, Great Plains.

Reithrodontomys montanus griseus Bailey.—The Biological Survey Collection contains 21 specimens of this harvest mouse. It occurs frequently in barn-owl pellets. It is a grassland species and is probably confined to the intermontane meadows. Distribution, Great Plains.

Reithrodontomys fulvescens laceyi J. A. Allen.—The Mount Scott specimens referred to by Howell (1914) were examined by Russell (1953) and partially provided the basis for resurrecting the form *laceyi*. The Wichita Mountains form the northern limit of the range of this subspecies. No additional specimens have been recorded, nor has the species appeared in material recovered from owl pellets. Distribution, Great Plains.

Peromyscus maniculatus luteus Osgood.—The prairie deer mice of the western part of Oklahoma have been assigned either to *bairdi* or *nebrascensis* by various authors. However, Jones (1958) has shown that the name *nebrascensis* has been misapplied, and that the mouse of the eastern plains should be called *luteus*. The prairie deer mouse is confined to the upland meadows of the refuge. The rocky hills and bottomland forests are occupied by other species of *Peromyscus*, each being confined rather precisely to its ecological niche. Distribution, Great Plains.

Peromyscus boylei attwateri J. A. Allen.—This species of *Peromyscus* is found throughout the refuge in rocky areas. It is abundant on every mountain and may be trapped on any rocky outcrop. The Biological Survey Collection contains a large series of this form, as does also the Oklahoma State University Museum. Distribution, Great Plains.

Peromyscus leucopus leucopus (Rafinesque).—The white-footed mouse of western Oklahoma has in the past been assigned to numerous races. The names *texensis*, *noveboracensis* and *aridulus* have been used for populations occupying all or parts of western Oklahoma. For a forest-dwelling species whose range in the plains consists of fingerlike westward extensions of woodland, the name of the eastern woodland form seems logically applicable. The writers have not made a critical evaluation of *P. leucopus* from the refuge, but refer them, as do Hall and Kelson (*op. cit.*), to the subspecies *leucopus*. The species is limited to wooded areas, especially along stream borders. Distribution, Austroriparian.

Sigmodon hispidus texianus (Audubon and Bachman).—The cotton rat is one of the most abundant small mammals on the refuge, and is certainly the most abundant and characteristic species of the intermontane meadows. Its numbers reflect the improvement of the range under proper grazing conditions. Bailey noted the abundance of cotton rats in favored places in 1934. The rats are extremely vulnerable to fires, which not infrequently sweep over parts of the refuge. The rocky nature of the soil makes it impossible for most of the rats to have subterranean refuges, and those which do not are at the mercy of the flames. The predominance of cotton-rat remains in barn-owl pellets attests to their abundance. Distribution, Great Plains.

Neotoma floridana osagensis Blair.—Early reports of wood rats from southern Oklahoma assigned specimens to the race *attwateri*. However, when Blair (1939*a*) described the race *osagensis*, he assigned all Oklahoma specimens to it, including those from the Wichita Mountains. Apparently *osagensis* and *attwateri* intergrade where their ranges are restricted within the Cross-Timbers belts, which traverse the Grand Prairie of northern Texas. In the refuge, the Florida wood rat is found wherever cover is available in the form of either rocks or woods. It is most numerous in the rugged mountain sectors. Only the intermontane meadows are free of it. Distribution, Austroriparian.

Microtus pinetorum nemoralis Bailey.—The Biological Survey Collection contains five pine mice collected on the refuge by McMurry. Two collected by O. J. Murie are in the

Refuge Collection. No other specimens are known, but Bailey reported their signs on Mount Scott and other high peaks where the spaces between the rocks are filled with lush vegetation. Owl pellets have yielded only a single fragment of this species. The Wichita Mountains mark the western limit of range for this species in Oklahoma. Distribution, Austroriparian.

Rattus norvegicus (Berkenhout).—Norway rats are occasionally found about buildings on the refuge. They apparently never have been numerous. Exotic.

Mus musculus brevirostris Waterhouse.—The house mouse is uncommon on the refuge, and as far as known is exclusively edificarian. Exotic.

Erethizon dorsatum bruneri Swenk.—Only one porcupine has ever been reported from the Wichita Mountains. McMurry (1944) reported one from near the Indiahoma gate, but no signs of porcupines have been seen since. He referred his specimen to the subspecies *bruneri*, which is correct if the specimen was native. Possibly the animal was imported, in which case it might either be *bruneri* or some other race of yellow-haired porcupine. Distribution, southern Rocky Mountain.

Myocastor coypus (E. Geoffroy-Saint-Hilaire).—A male of this species was caught in a live-trap set for raccoons by Lee R. Nix, an employee of the Oklahoma Department of Wildlife Conservation. The animal was caught 25 August 1960, in the drain between Lake Elmer Thomas and Lake Lawtonka, at the eastern edge of the refuge. On 2 September 1960, the junior author examined the animal, which was being kept alive by Mr. Nix, at Medicine Park. The origin of this specimen is not known. Exotic.

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[Contribution No. 316, Oklahoma State Univ., Dept. of Zoology and Research Foundation.]

Oklahoma State Univ., Stillwater, and Wichita Mountains Wildlife Refuge, Cache, Okla.
Received 20 June 1960.

JUNIPER SEED: A WINTER FOOD OF RED SQUIRRELS IN MASSACHUSETTS

By Herschel G. Abbott and William H. Belig

Abstract: Red squirrels were found to feed heavily on the fruits of common juniper during the winter months of January, February and March. Only the seeds were eaten, the fleshy outer portions of the fruits being discarded to form conspicuous middens beneath the branches of the juniper. Some middens contained the remnants of several hundred fruits as well as numerous branchlets removed in the feeding process. Trails and tunnels in the snow furnished additional evidence of squirrel activity. Natural tunnels or passageways formed by the snow-covered branches of the juniper were used extensively by these mammals. This plant, therefore, not only serves as a source of winter food but also provides protective cover for other activities such as playing and possibly breeding.

Common juniper (*Juniperus communis* L.) is the major constituent of a vegetation complex often referred to as an abandoned juniper pasture. Several thousand acres of these pastures, in different stages of succession and of varying densities, exist in western Massachusetts. The classification of such lands as either pasture, field or forest is of doubtful merit from the viewpoint of present land use, for they possess little if any value for agricultural or lumbering purposes. However, they are frequented by many species of birds and mammals, and several interesting phenomena associated with the activities of these animals have been observed by the senior author. One of these phenomena is the existence of animal middens composed of the fleshy parts of juniper fruits (Plate I, *A*). These middens, which were first noticed during the summer of 1955, were of undetermined origin until the recent discovery that they are made by red squirrels, *Tamiasciurus hudsonicus*, while feeding upon the seeds of juniper in winter.

A description of this feeding and the observations which were conducted to determine the species of animal causing it are presented here.

INITIAL OBSERVATIONS

The first discovery of accumulations of ripened juniper fruits with their seeds removed, lying on the ground beneath the semi-prostrate branches of this plant, prompted a search for other such accumulations and for evidence as to their origin. Further investigations showed this type of feeding to be a common occurrence in most juniper pastures visited.

It was first thought that birds were responsible for this feeding, as they were by far the most numerous and conspicuous of all animals present at nearly all times of the year. Birds do consume appreciable numbers of these fruits, but there was no evidence that associated their feeding with the middens of juniper husks.

Small mammals, such as mice and voles, were investigated as suspects. White-footed mice, *Peromyscus leucopus*, and boreal red-backed voles, *Clethrionomys gapperi*, the two species known to be most prevalent on the area, were confined in laboratory cages and fed juniper fruits. They ate this

food with reluctance and consumed fleshy material as well as seeds, their manner of feeding in no respect resembling that of the animals responsible for the middens.

In September 1958, ten small study plots containing fruit-laden bushes were established in an accessible juniper pasture. The ground beneath these bushes was raked clean of old middens, juniper needles and other debris. Periodic visits were made to inspect these plots during the subsequent fall and winter months. No evidence of feeding was noted until late in February, at which time a number of middens were seen. Squirrel tracks in the snow were the only sign of mammal activity on the plots. One set of tracks in fresh snow was seen leading to and from a midden, thus furnishing circumstantial evidence that red squirrels were the animals concerned.

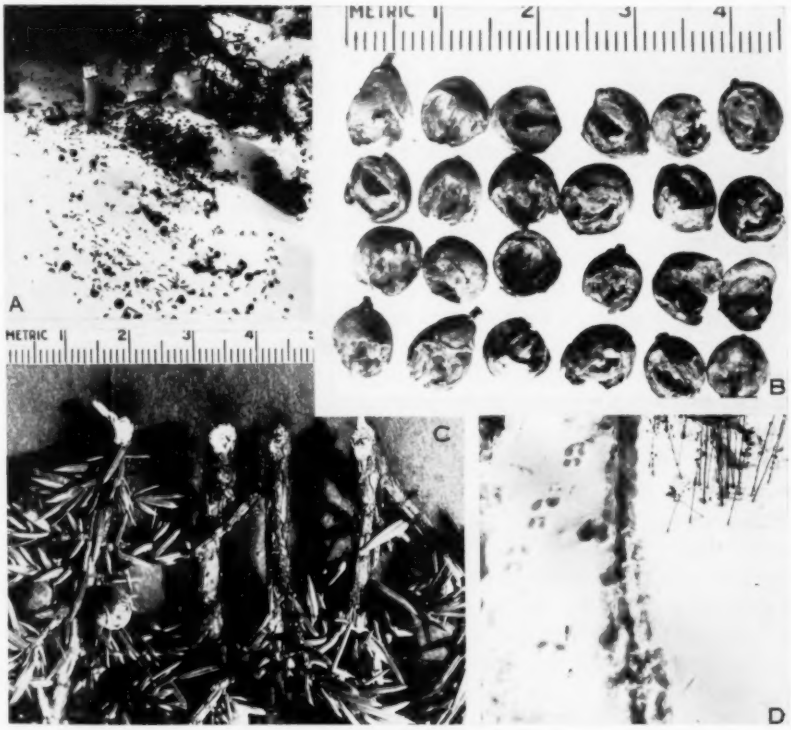

PLATE I

Feeding by red squirrels on common juniper. *A*, a midden of juniper fruits; *B*, fleshy remains of juniper fruits, with seeds removed, taken from a midden; *C*, small branches of juniper removed by squirrels while feeding on fruits; *D*, snow trail of squirrels leading to juniper stand.

During the fall and winter of 1959–60, the same juniper pasture was again investigated. The first snow of the season fell on 18 December, but no evidence of feeding was found until several weeks later. The first middens were noted on 19 January, immediately following a snowstorm. No feeding on juniper is believed to have occurred prior to this date. Red squirrel tracks constituted the only animal signs associated with the middens.

During the following week, squirrel tracks became very numerous on the area and juniper fruits were heavily attacked, with many middens produced. This activity continued throughout the winter, reaching its peak in mid-February. The last observation of feeding was recorded on 9 March.

To further substantiate that red squirrels were feeding on the juniper seed, traps were set in the vicinity of middens, and several squirrels were captured. Two captives were brought into the laboratory and fed juniper fruits. Although these animals survived only a few days, they ate a number of the fruits offered them. Only the seeds were consumed and the discarded, fleshy portions of the fruits indicated a type of feeding identical to that which produced the middens in the field.

Nature of feeding.—Plate I, *B*, presents a photographic description of the nature of this feeding. A small cap or portion of the fleshy scales is chewed off, allowing extraction of the enclosed seed. Although no actual feeding was observed, several aspects of it are somewhat obvious.

Only branches supporting an abundance of ripened fruits are sought (fruits in several stages of development are often found on a single branch). A high degree of selectivity is demonstrated in choosing the most bountiful branches.

Some of the fruits can often be reached from the ground, especially when snow is present. However, other branches supporting attractive numbers of edible fruits may be somewhat beyond reach and are necessarily climbed by the animals.

The prickly character of juniper foliage apparently is bothersome to the squirrels for they frequently cut off branchlets which get in their way (Plate I, *C*). This removal of woody material suggests that the fruits are picked orally from the plants and that the face of the animal is sensitive to the mechanical obstruction presented by the sharpness of the juniper needles.

When feeding takes place from the lower and more prostrate branches, conspicuous middens are formed beneath the extremities of these branches. The more upright branches, whose fruit-bearing sections do not extend so far in a lateral direction, are the source of discarded fruit material which falls to the ground close to the base of the plant. When such branches are fed upon, the middens produced are usually inconspicuous.

Middens vary in size and volume of contents, depending upon the intensity of feeding and the part of the plant furnishing the food. A midden formed by an animal feeding for only a brief time will contain the remains of only

a few fruits. Repeated feeding from the same branch will increase the volume of material so that it may contain the remnants of several hundred fruits as well as numerous twigs removed in the course of feeding.

Time of feeding.—On three mornings during the height of squirrel activity, predawn watches were conducted to observe the animals in the act of feeding and to record the time of day when feeding took place. Ten squirrels were seen entering the juniper cover from an adjacent hardwood stand. All ten observations were made during the first half-hour after sunrise. Several other animals were heard chattering within the juniper and apparently had approached the area from sectors not under observation. No animals were seen in the act of feeding.

Trapping results furnished supporting evidence that most feeding activity began early in the morning. Eleven animals were captured, all catches occurring prior to 10:00 AM. These observations agree with those of Hamilton (1939) who has noted that red squirrels are most active in the early morning.

The duration of juniper feeding is not known, for once within the protective cover of the juniper, the squirrels are well concealed. It is known that several hours of the day are spent within the confines of the juniper, but activities other than feeding probably take place during this period.

Trails and tunnels.—A characteristic habit of the red squirrel is the building of trails and tunnels in the snow. Seton (1929), Hatt (1929) and others have described these snow tunnels. Hatt refers to these tunnels as interlacing networks which facilitate the search for food and also lead to food caches which have been stored. It has been suggested that some of the passageways may be used for play.

The most conspicuous evidence of red squirrel activities in the juniper, other than the middens produced by feeding, was the trails and tunnels made in the snow. Several heavily traveled trails were found at different locations along the borders of the juniper stands (Plate I, *D*). These were not extensive and generally resulted from frequent short trips to the juniper from nearby trees or stumps. These trails were found immediately following a snowstorm and were usually abandoned once the snow hardened to permit traveling upon its surface.

Once within the borders of the main juniper stand, very little snow removal work is required to gain entrance to a multitude of natural tunnels formed by the prostrate branches of the snow-covered juniper. The animals select a few points of entry, some of them well concealed, and travel for appreciable distances in these natural passageways. They come to the surface only when a break in the juniper is encountered. Upon surfacing for a brief period, the subway is again used after a new point of entry is selected. Many small branches chewed off by the squirrels were collected from these passageways. Such clippings, which were not associated with feeding, were presumably removed to enhance movement along the tunnels.

DISCUSSION

The red squirrel has a reputation for extravagance in its feeding habits and for eating many different types of food (Hamilton, 1943). This study indicates that, in western Massachusetts, common juniper is one of the more important species in its winter diet. It is believed that the consumption of juniper seeds in the wild has not been previously reported. Seton (1929) vaguely mentioned ornamental "cedars and junipers" as being fed upon and Hatt (1929) found that captive animals ate the seeds of junipers but left the remainder of the fruit untouched.

Juniper stands of high density also provide the red squirrel with excellent cover in winter, especially when there is snow upon the ground. The presence of natural passageways formed by the snow-laden branches allows the squirrels to move freely throughout the juniper, safely hidden from view of their enemies. In addition to this protection from observation, the juniper constitutes a mechanical barrier to the larger predatory animals. This plant, therefore, not only serves as a bountiful source of winter food, but also furnishes protective cover for other activities, such as playing and possibly breeding. It is perhaps significant that the height of feeding activity occurs during February, when breeding takes place. This period generally coincides with the time when stored foods are depleted, other sources are at a minimum, and snow cover is at its greatest.

As the period extends into March and the temperatures increase, snow accumulations lessen, buds upon the hardwoods become greatly enlarged, and the juniper no longer is utilized even though many uneaten fruits remain.

ACKNOWLEDGMENTS

This investigation was supported by the Massachusetts Agricultural Experiment Station and the Massachusetts Cooperative Wildlife Research Unit which is jointly sponsored by the U. S. Fish and Wildlife Service, the Massachusetts Division of Fisheries and Game, the University of Massachusetts, and the Wildlife Management Institute.

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CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES OF THE MILK OF THE COLLARED PECCARY

By Lyle K. Sowls, Vearl R. Smith, Robert Jenness, Robert E. Sloan and Edna Regehr

Abstract: Samples of milk from the collared peccary, *Pecari tajacu*, were analyzed for chemical composition and physical properties. Average chemical composition of the two specimens of mature milk were as follows: fat 3.55%, lactose 6.55%, total protein 5.8%, total solids 16.45%, pH 6.64, sp gr 1.0441, nonprotein N (mg/100 ml) 81.5. Colostrum milk differed in composition from mature milk in that the casein was slightly lower and the whey protein higher which is comparable to other species. There are two principal sugar components in peccary milk. On a paper chromatogram the one in greatest concentration corresponded in speed to lactose. The other sugar probably represented an oligosaccharide.

In comparison to domestic sow milk the milk of the collared peccary is lower in fat and total solids. The range is so varied in other constituents that comparisons were valueless with the limited number of samples. Caseins of the peccary are similar to those of the domestic sow. The whey proteins of the peccary are similar to those of the domestic sow for mature and colostrum milk.

There is no information in the literature on the chemical composition and physical properties of the milk of the collared peccary, *Pecari tajacu*. An effort is being made to obtain information on the composition of milk of species not previously available to better study the phylogeny of mammals. This is a report in that series.

EXPERIMENTAL PROCEDURES

The animals used in this study were from a colony of collared peccaries maintained by the Arizona Cooperative Wildlife Research Unit (University of Arizona, Arizona Game and Fish Department, U. S. Fish and Wildlife Service, Wildlife Management Institute cooperating). The original animals for the colony were trapped from wild herds indigenous to the Tucson area of Arizona.

The female peccary has four functional mammae with only small storage capacity. In order to obtain sufficient quantities of milk for analysis the young were removed from the sow 12 hours previous to a milking. The method of restraining the sow for milking is described by Neal (1959). Intravenous injections of oxytocin were made into the cephalic vein of the foreleg to facilitate an expulsion of milk.

One female was milked 18 days after giving birth to twins. Milk was obtained from the same female 6 days after a subsequent parturition. A third sample of milk was obtained from a second female peccary shortly after parturition but before the young had nursed.

Milk samples were frozen and shipped by air from Tucson to St. Paul for analysis. Fat was determined by the Babcock method, using a 1-ml sample

with a Babcock skim-milk bottle. Total solids and ash were determined on a 1-ml sample weighed into a platinum dish, and dried in a vacuum oven at 70°C for 8 hours followed by ashing at 600°C overnight. Lactose was analyzed by the picric acid reduction method (Perry and Doan, 1950). Casein, whey proteins, and nonprotein nitrogen were determined with the Rowland scheme for separation coupled with micro-Kjeldahl analysis for nitrogen (Larson and Jenness, 1950). A chainomatic Westphal balance was used to determine specific gravity at 20°C/20°C after the sample had been warmed briefly to 40°C. The pH was determined with a Beckman Model G pH meter.

Milk fat was removed by centrifugation to form a cream layer. Casein was precipitated from the centrifuged milk by acidification to a point of optimum separation, pH 4.6, after dilution with an equal volume of distilled water. The precipitated casein was washed with distilled water and freeze-dried. Wheys were dialyzed against water to remove the dialyzable fraction which was saved for qualitative analyses of the sugars. The dialyzed whey proteins were freeze-dried.

Paper electrophoretic analyses were made with the Spinco Model R apparatus and the Spinco Analytrol. Caseins were run in veronal buffer at pH 8.6, ionic strength 0.05 for 16 hours at 5°C, and whey proteins in veronal at pH 8.6, ionic strength 0.075 for 16 hours at room temperature. A casein or whey protein mixture prepared from a composite sample of cow milk was included in each electrophoretic run. This enabled the adjustment of patterns to provide comparisons between runs.

Moving boundary electrophoresis was performed with the Klett–Tiselius apparatus using a 2-ml cell and a protein solution containing 1.5 g/100 ml in veronal buffer, pH 8.6, ionic strength 0.1.

Sugar solutions for qualitative chromatography were prepared by deionization of whey dialysates with a monobed resin (Amberlite MB-3) and concen-

TABLE 1.—*Analyses of peccary milk and comparison with samples from domestic sow*

	Normal milk		Colostrum	4 samples from 4 domestic sows
	Specimen 1 Sow 1	Specimen 2 Sow 1	Specimen 3 Sow 2	
Days from birth of young to sampling of milk	18	6	0	25–31
Fat, %	4.0	3.1	4.8	6.4–7.4
Lactose, %	6.4	6.7	5.2	5.1–5.7
Total protein, %	5.1	5.7	6.0	3.8–5.2
Casein, %	3.7	4.2	3.2	2.2–3.0
Whey protein, %	1.4	1.5	2.8	1.7–2.2
Ash, %	–	–	0.64	—
Total solids, %	16.7	16.2	18.2	18.0–19.4
pH	6.68	6.60	6.40	6.7–7.0
sp gr at 20°C/20°C	1.0441	–	1.0404	1.0336–1.0372
Nonprotein N (mg/100 ml)	88	75	75	48–78

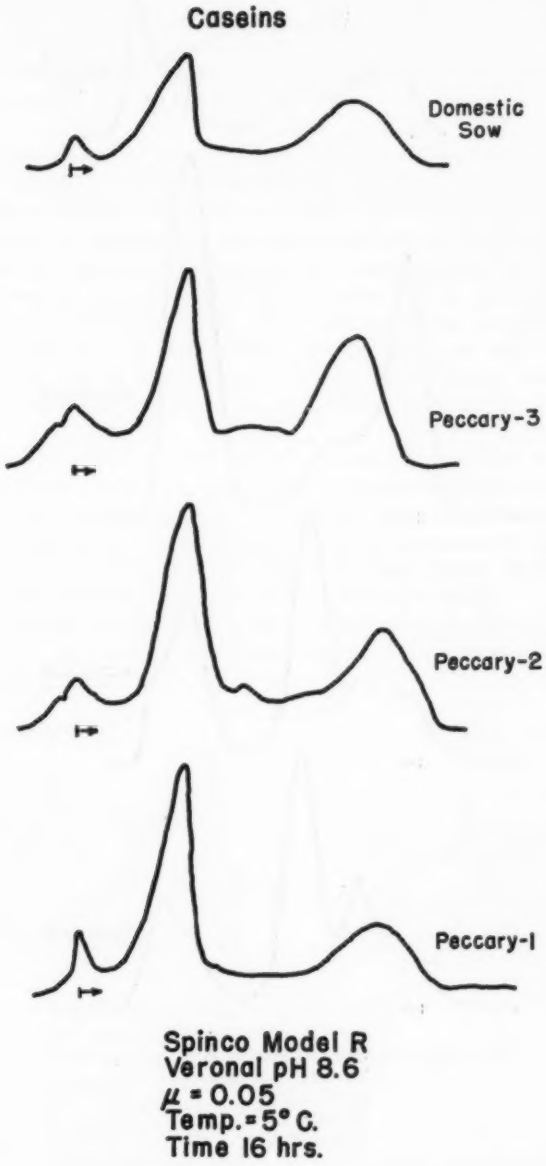

FIG. 1.—Paper electrophoretic patterns—casein.

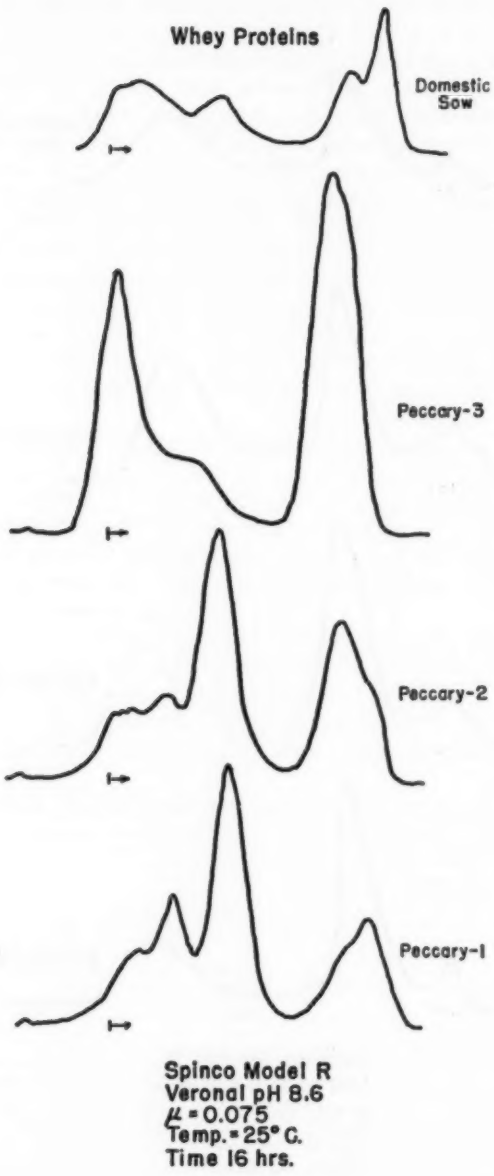

FIG. 2.—Paper electrophoretic patterns—whey proteins.

tration to a small volume. Chromatograms were developed with an ethyl acetate, pyridine, water solvent in the ratio of 10:4:3 on Whatman No. 1 filter paper for 16–20 hours and sprayed with ammoniacal silver nitrate for detection of individual reducing spots. A standard solution containing glucose, galactose and lactose was included in each run.

RESULTS

Table 1 shows the gross chemical analysis of the three samples. There is considerable difference in composition between samples 1 and 2 from the same female but from different lactations and times after birth of the young. The largest difference is between the per cent of fat and of nonprotein nitrogen. Stage of lactation, which in other species has a marked effect on the composition of milk, may account for the differences observed in this species. Specimen 3 of colostrum differs from the others in being higher in fat and lower in lactose. This difference in composition between colostrum and mature milk is comparable to that of other species. The casein is slightly lower and the whey protein is much higher than in the mature milk, as is true for other species.

For comparative purposes, data for four samples of domestic sow milk are also shown in Table 1. The per cent of fat in domestic sow milk is considerably higher than in that of the collared peccary. The total solids for the milk of the domestic sow appears to be a little higher than for the peccary. There is considerable range in the other milk constituents for both species which limits the value of comparisons of data from a small number of samples.

The caseins of the peccary appear electrophoretically similar to those of the domestic sow (Figs. 1 and 3). Both exhibit two principal components in paper

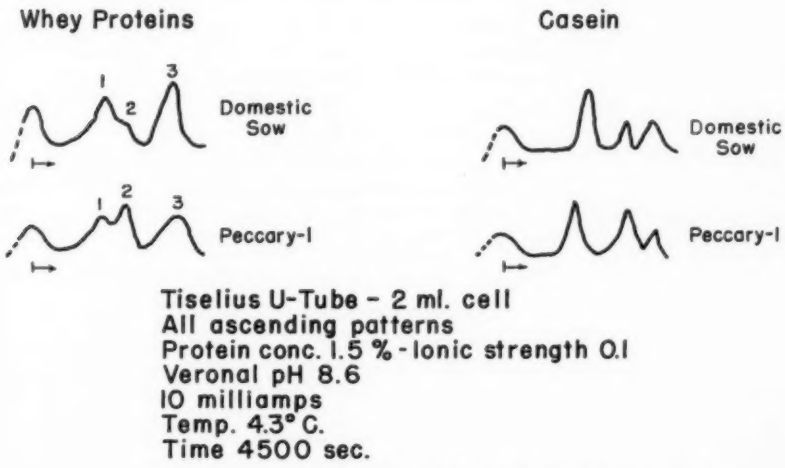

FIG. 3.—Patterns of peccary and sow milk proteins.

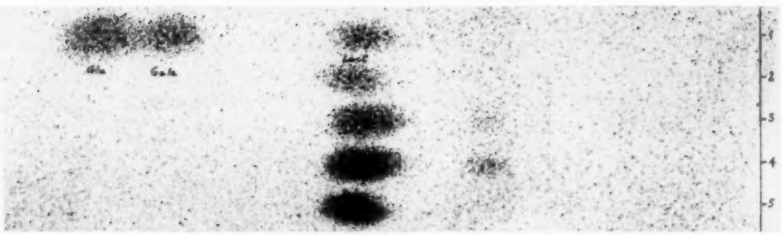

PLATE I

Paper chromatogram of sugars from peccary milk—1, control containing glucose, galactose and lactose; 2, crystals from concentrated solution from specimen 2; 3, concentrated solution from specimen 2; 4, concentrated solution from specimen 3; 5, crystals from concentrated solution from specimen 3.

electrophoresis, the slower one being present in much greater concentration. The faster component appears to split into two subfractions in the moving boundary electrophoresis.

The whey proteins of the peccary contain components that are electrophoretically similar to those of the domestic sow but the proportions of individual components are different for the two species (Figs. 2 and 3). Whey from the colostrum (specimen 3) contained a high concentration of slow-moving components which undoubtedly represent the immune globulins commonly found in colostrums. Similar patterns with high contents of slow-moving components were found for the whey of domestic sow colostrum by Deutsch (1947) and by Foster *et al.* (1951).

A paper chromatogram of concentrated dialysate from specimen 1 revealed two principal sugar components. One, present in by far the greater concentration, corresponded in speed to lactose. The other moved considerably more slowly than lactose and probably represented an oligosaccharide of some sort.

Further information on the carbohydrates is given by the chromatograms obtained from specimens 2 and 3 shown in Plate I. Lactose appears to be the overwhelming carbohydrate in both specimens, but another component with $R_L = 0.67$ appears in both cases. This second component was present in significantly higher concentration in the colostrum (specimen 3) than in the normal milk (specimen 2). Plate I also shows that crystals which formed in concentrated deionized solutions of both specimens appeared to be lactose.

ACKNOWLEDGMENTS

The authors are grateful to the following for assistance in obtaining milk samples: C. R. Hungerford, Joseph P. McCraren, Thomas A. Eddy, Timothy B. Knopp, Harley G. Shaw and Richard W. Rigby.

A grant from the National Science Foundation has supported a study of reproduction in the collared peccary carried out by the Arizona Cooperative Wildlife Research Unit. A grant from the Graduate School, University of Minnesota, partially supported the analytical phases of this work.

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Univ. of Arizona, Tucson (Sowls, Smith) *and Univ. of Minnesota, St. Paul* (Jenness, Sloan, Regehr). *Received 17 November 1960.*

PERSONAL NOTICES

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KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

URGENTLY NEEDED—*Serum of foreign pinnipeds* for a comparative study involving electrophoretic and immunologic work on pinnipeds of the world. Directions for preservation and shipping sent on request; we assume shipping costs. Murray L. Johnson, Museum of Natural History, University of Puget Sound, Tacoma 6, Washington, U. S. A.

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GENERAL NOTES

SOREX LONGIROSTRIS IN MISSISSIPPI

Cook (J. Mamm., 23: 218, 1942) reported the southeastern shrew, *Sorex longirostris longirostris*, from three counties in Mississippi—Jones and Wayne counties in the southeastern part of the state, and Wilkinson County in the extreme southwest; no specific localities were mentioned. Two additional records that help to clarify the distribution of *S. l. longirostris* in Mississippi recently have come to our attention.

On 22 March 1959, Max C. Thompson trapped a southeastern shrew in Bienville National Forest, ⅗ mile east of the corporate limits of Morton, Scott County, in the central part of the state. The specimen, an adult male (KU 79897), weighed 3.8 grams and had the following external and cranial measurements: total length, 83 mm; length of tail vertebrae, 28; length of hind foot, 10; length of ear from notch, 6; condylobasal length, 14.4; cranial breadth, 7.8; interorbital breadth, 3.2; length of maxillary toothrow, 5.5. In January 1960, another southeastern shrew was obtained at Greenwood, Leflore County, approximately 85 miles northwest of Morton. This specimen (KU 82828), preserved in alcohol, was transmitted to us by D. E. Ferguson of Mississippi State University.

Although Hall and Kelson (THE MAMMALS OF NORTH AMERICA, p. 29, map 14, 1959) seemingly overlooked Cook's records of *S. l. longirostris*, their estimate of the distribution of the species in Mississippi is only slightly in error when compared with the records herein discussed. The known records from Mississippi lend support to the inclusion by them of a part of Louisiana wtihin the range of the southeastern shrew.—J. KNOX JONES, JR., AND CHARLES A. LONG, *Museum of Natural History, Univ. of Kansas, Lawrence. Received 20 June 1960.*

FLYING FOXES DRINKING SEA WATER

I was very interested in Ripley's account (J. Mamm., 41: 264, 1960) of a Netherlands official who observed flying foxes coming down to the surface of the sea off Hollandia, and attempting to pick up floating fruits. I wonder if this was the real reason for the performance described; for I have seen something similar, and came to the conclusion that the flying foxes were merely drinking the sea water—probably for the sake of mineral salts which they needed and which their diet of fruit juices and nectar might not supply in adequate quantities.

I first saw flying foxes drinking salt water on the wing in New South Wales, in 1930, when I was carrying out an ecological study of the Australian species of *Pteropus*. I only learned after making the observation that the Nambucca River, at that point, was tidal and salty; and so I was inclined to dismiss the record as a case of faulty observation—it was half-light at the time—but it stuck in my memory.

In 1945 I was stationed on Bougainville, in the Solomons. At one stage I was camped for some days on a narrow spit of land on the west coast of the island, between the sea and an extensive sago swamp. Every evening just after sunset, loose flocks of flying foxes flew over our camp to the sea; and with Dr. I. M. Mackerras I used to sit on the beach and watch them. After noticing one of the animals flying just above the water, and making V-shaped lap-marks on the surface, we decided to keep individual bats under continuous observation. We did this for several evenings in succession.

The casual observer would have seen some scores (or hundreds) of the big bats flying hither and thither over the sea, now high and now low, with no obvious purpose, and continuing their evolutions until it was too dark to see them clearly. When individuals were kept under observation from the moment they passed above us to join their fellows offshore until they flew inland a few minutes later, the apparently aimless exercise was seen to be a very purposeful performance. Every individual we watched flew right down to the sea surface at least once (as I recollect most did it twice, and a few as many as three times) and, if the water was calm enough, we could see the actual lap-splashes. Having cruised

up and down for a while, and having drunk from the sea once or more, each bat in turn left the flying mob and headed inland, presumably to set out on its nightly food search. I am afraid I did not trouble, at the time, to identify the species of flying fox involved.—FRANCIS N. RATCLIFFE, *Wildlife Sec., C.S.I.R.O., Canberra, Australia.* *Received 15 August 1960.*

THE BIG FREE-TAILED BAT IN SOUTHERN TEXAS

On the morning of 23 December 1959, I captured an adult male *Tadarida molossa* at the Welder Wildlife Foundation Refuge, 7 miles north of Sinton, San Patricio County, Texas. This provides the first recorded location for this species in southern Texas and the third known locality for the state.

The specimen reported herein was found hanging on a screen door at the Refuge headquarters at about 11:00 AM by George Wiliges, who informed me of its presence. The bat was kept alive in the laboratory for two days and crawled actively about its cage. There was no evidence of sickness or injury.

This locality is approximately 350 airline miles WSW of the Chisos Mountains, Brewster County, the nearest recorded locality in the state (Borell, J. Mamm., 20: 65–68, 1939). The only other published record for this species is Lubbock, Lubbock County (Milstead and Tinkle, Southwestern Nat., 4: 134–142, 1959). Sinton is about 250 miles north of the northern limits of the species range in Mexico as interpreted by Hall and Kelson (MAMMALS OF NORTH AMERICA, p. 208, 1959).

Our knowledge of the habits and ranges of the species of bats in Texas is extremely limited. This is particularly true of rare species such as *Tadarida molossa*. It is impossible to state, on the basis of available information, whether this record represents an actual range extension or a stray individual.

External measurements of the fresh specimen were: total length, 133; tail, 46; hind foot, 10; ear, 31; forearm, 61 mm. The specimen has been deposited in the Welded Wildlife Foundation collection (WWF 195).—GERALD G. RAUN, *Dept. of Zoology, Univ. of Texas, Austin 12.* *Received 23 May 1960.*

[Contribution No. 52, Welder Wildlife Foundation.]

GESTATION PERIOD OF THE LION MARMOSET

Rabb and Rowell (J. Mamm., 41: 401, 1960) gave evidence from their observations of a breeding pair of lion marmosets, *Leontocebus rosalia*, at the Chicago Zoological Park that the period of gestation in this primate does not exceed 134 days. The writer wishes to corroborate their statement with further evidence gathered from a breeding pair of these marmosets at the Philadelphia Zoo.

The Philadephia lion marmosets were obtained from the New York firm of Louis Ruhe, Inc. on 15 January 1957. In the interval between that date and 20 August 1960, they produced six litters, consisting of five sets of twins and one set of triplets. During 1957 and 1958 they produced young just once yearly—twins on 8 August 1957 and again on 7 July 1958. Since then they have had two litters a year.

The interval between a set of twins born 22 April 1959 and a set of triplets born 1 September 1959 was exactly 132 days. The interval between a set of twins born 9 April 1960 and another set of twins born 20 August 1960 was just 133 days. From this evidence it appears that these primates copulate almost immediately following parturition and the gestation period can, rather definitely, be established at from 132 to 134 days. It is interesting to note that the breeding activity of the Philadelphia lion marmosets seems to follow a very regular cycle, with a long period of quiescence after the late summer litters. Since they are kept in a thermostatically controlled nest-box (Ulmer, All-Pets Mag., 31: 8–9, 1960), temperature apparently is not a factor. This, in turn, prompts speculation that the number of hours of daylight might be responsible, but the fact that the litter born 9 April 1960

was conceived on or about 29 November 1959 seems to negate this.—Frederick A. Ulmer, Jr., *Zoological Society of Philadelphia, Philadelphia, Pennsylvania. Received 25 August 1960.*

A LARGE COTTONTAIL LITTER

On the morning of 27 May 1950, a very small and severely weakened cottontail, *Sylvilagus floridanus mallurus* (Thomas), was captured as it struggled over a lawn about 10 feet from the corner of a temporary barracks on the North Carolina State College campus in Raleigh, North Carolina. A search of the area revealed three more baby rabbits, equally malnourished, just under the corner of the building; all three were easily caught by hand. One of the three rabbits was captured only a foot away from a nest made of old grass and shredded rope. The nest, 7½ inches in diameter and 5 inches deep, was located against the inside corner of a cinderblock post which supported the southwest corner of the building. Upon examination, the nest was found to contain five additional baby rabbits, four of them dead and one almost dead. All young in the nest were covered with ants, the four dead rabbits so badly damaged by ants that they were discarded. Skins were made of the remaining five. A careful search of the area revealed no other young or nests. With the exception of the one rabbit which was found less than 15 feet away, the rabbits were within 3 feet of the nest when captured. The eyes of each of the young had opened. All were approximately the same size and were believed to be the same age. The five young that were found alive weighed 32.3, 34.6, 38.3, 38.4 and 41.0 grams, whereas normal nestling rabbits of comparable age weigh approximately 60 grams.

A day or two before the young were found, an adult rabbit was killed by a car on the road about 25 yards from the nest location. After the discovery of the litter, a search was made for the dead adult to determine its sex, but the carcass had been removed. Prior to the time the rabbit was killed by the car, an adult cottontail was seen regularly at dusk and early morning in the small open area between the barracks. Subsequent to finding the litter, no adult rabbits were observed in the mall area. It is possible that the adult which was killed was the parent of the young rabbits. The conditions under which the litter was found indicate that the young could be from a single female. This report seems to be the first of a litter this large in *S. f. mallurus*. A count of 12 small embryos (Dalke, The cottontail rabbits in Connecticut; Bull. 65, State of Conn. Pub. Doc. No. 47, 1942) indicates the possibility of an even larger litter, although Dalke stated that resorption would probably reduce the litter to a more normal size.

Hendrickson (Ames Forester, 31: 59–73, 1943) reported nine *Sylvilagus f. mearnsii*, which he believed were from one mother, from one nest. He also recorded litters of 11 and 12, each of which contained young of two sizes, indicating common usage of a single nest by more than one female. Lemke (J. Mamm., 38: 275, 1938) reported 10 embryos approximately 25 days old in one *S. f. mearnsii* killed in Wisconsin; and Bruna (Ky. Rabbit Invest., Fed. Aid Proj. W-26-R, 1952; mimeo.) reported a litter of 9 in Kentucky. Kirkpatrick's recent report (J. Mamm., 41: 119–120, 1960) of 12 young *S. f. mearnsii*, all approximately the same size and all in a single nest, suggests the possibility that the cottontail, *Sylvilagus floridanus*, may be capable of raising unusually large litters on rare occasions. —Frederick S. Barkalow, Jr., *Dept. of Zoology, North Carolina State College, Raleigh. Received 24 May 1960.*

ERYTHRISM IN AN ALABAMA COTTONTAIL

A number of mammals occasionally display the reddish pelege coloration known as erythrism. Among these are the squirrels, opossums, raccoons, the cinnamon bear and bats. The trait has also been genetically isolated in a great variety of domesticated mammals, including the European hare. However, a search of the literature revealed no record of this color condition occurring in the genus *Sylvilagus*.

A juvenile female cottontail, *Sylvilagus floridanus alacer*, that displayed erythrism was killed by Modie Henderson on 19 October 1958 at Valhermosa Springs, Morgan County, Alabama. The specimen, a study skin and skull (No. M-1774), is now deposited in the University of Alabama Department of Biology collections.

Measurements of the skin and skull (in mm) are as follows: Total length 263; tail vertebrae 50; hind foot 73; ear from notch in wet skin 49; basilar length 42.6; length of nasals 22.7; breadth of rostrum 11.6; interorbital breadth 13.3; parietal breadth 21.5; diameter of bullae 10.2; interparietal bone 07.6; weight 9.9 ounces.

This specimen is in juvenile pelage. It is uniformly rufinistic with the top of the head deep Ochraceous-Buff and a white blaze in center of forehead; dorsum deep Ochraceous-Buff grading into Light Buff on sides of body; venter pale Light Buff; flanks Light to Warm Buff; top of tail Cinnamon; nape of neck rich Cinnamon; front of forelegs rich Cinnamon with forefeet Light Ochraceous Buff; outside of lower legs deep Cinnamon shading into light Ochraceous Buff on tops of hind feet (capitalized color terms after Ridgway, Color Standards and Color Nomenclature, 1912).—Dan C. Hollman, *Dept. of Biology, Univ. of Alabama, University, Ala. Received 5 August 1960.*

ANGORA COTTONTAIL FROM GEORGIA

Recently received, through the courtesy of George C. Moore of the Georgia Game & Fish Commission, was an aberrant rabbit shot by a sportsman near Atlanta in early December 1959. It was described as resembling a cottontail in all respects except that "it had long, bluish, silky-looking hairs over most of its body." On comparison with other specimens from Georgia, the skull appears typical of *Sylvilagus floridanus mallurus*. The ears, feet and tail are those of a normal eastern cottontail. Elsewhere the pelage consists of soft, gray, curly hairs like those of an Angora rabbit or cat. This is particularly striking on the back and sides, but a few abnormal hairs are also scattered on the forehead and cheeks. The longest hairs, on the back, are about 80 mm in length. The specimen is a female. Standard measurements are: total length 390, tail 45, hind foot 83, ear from notch 53 mm. It is entered in the Biological Survey's collection as No. 288048, skin and skull. Some abnormal physiological or dietary condition may have produced this freak, or it may be a mutant lacking guard hairs after the fashion of the Samson fox.

A very similar case was reported by Ludwig Kumlien (Wisc. Nat., 1: 89, 1891). He told of a Wisconsin cottontail, apparently normal in most respects, but in which "the body was covered with long silky ashy-blue hair, divided lengthwise dorsally, and falling gracefully down the sides, hanging like a fine fringe on either side." In this instance, the sex could not be determined; dissection indicated gynandromorphic tendencies, which may have had a bearing on the peculiar condition. I am grateful to H. H. T. Jackson for calling my attention to this earlier case.—Richard H. Manville, *U. S. Fish and Wildlife Service, Washington, D. C. Received 8 April 1960.*

WOODCHUCK IN OKLAHOMA AND SOUTHEASTERN KANSAS

On 1 April 1960, Arthur Davis and Robert Wilcox shot an adult woodchuck, *Marmota monax*, on the Davis Farm, 2 miles southwest of the Tri-state Monument, Ottawa County, Oklahoma, and subsequently donated it to the Museum of Natural History, University of Kansas. The specimen (KU 81877, skin and skull), a large, lactating female, is the first of the species to be examined from Oklahoma, although sight records have been reported from that state (Blair, Amer. Midl. Nat., 22: 110, 1939). To my knowledge, woodchucks have been obtained no nearer this Oklahoman locality than Fayetteville, Washington County, Arkansas (Sealander, Amer. Midl. Nat., 56: 269, 1956), approximately 65 miles southeastward. Black (J. Mamm., 16: 320, 1935) mentions examining "a specimen from McDonald County," Missouri, also to the southeastward. Cockrum (Univ. Kansas Publ.,

Mus. Nat. Hist., 7: 119, 1952) has recorded the species from approximately 100 miles to the northwestward at Hamilton, Greenwood County, Kansas, and from approximately 100 miles to the northward at a place 5½ miles southeast of Fontana, Linn County, Kansas. The female from Oklahoma has a higher sagittal crest, paler upper parts, and a relatively shorter (90 mm) hind foot than *Marmota monax bunkeri* (see below), and in these respects agrees with *Marmota monax monax*, to which it is referred. Measurements of the Oklahoman specimen are as follows: total length, 625 mm; length of tail vertebrae, 161; length of hind foot, 90; and length of ear (from notch), 31. It was shot in a tree near a high rocky bluff at the edge of a grassy clearing in a wooded area.

According to several local inhabitants, the woodchuck is fairly common in northeastern Oklahoma, at least as far westward as Miami, in the Neosho River watershed.

Three specimens of *M. monax* from southeastern Kansas are in the collection at Kansas State College of Pittsburg. One is a small but adult female (KSCP 53-B, skin only) from the "West edge of Pittsburg," Crawford County, Kansas, obtained on 14 May 1959. Its dark feet and darker color elsewhere are as in topotypes of *bunkeri*, although the hind foot is short as in *monax* (12.7 per cent of total length). Cranial measurements of an adult (KSCP 178-B, skull only, probably male) from 4 miles west of Pittsburg, found in May 1959, and of an immature (possessing several milk teeth) specimen (KSCP 179-B, skull only) found dead on a road 2 miles west of nearby Frontenac, Crawford County, Kansas, on 15 September 1959, more closely resemble those of *monax* than those of *bunkeri*. The sagittal crest, as in *monax*, is well developed in both skulls from southeastern Kansas; *bunkeri* has a less well-developed sagittal crest. Assignment of these specimens to *M. m. monax* extends the known range of that subspecies into southeastern Kansas, from which area the woodchuck has not heretofore been reported.

The woodchuck now is fairly numerous in Crawford County, but there are indications (verbal reports of several farmers in this area) that the species has increased in numbers in the last decade. In extreme southeastern Kansas, 4 miles east of Baxter Springs, Cherokee County, on 8 May 1960, I observed a woodchuck in a rocky pasture. No woodchucks have been previously reported from Cherokee County, but probably the species is common there.—Charles A. Long, *Museum of Natural History, Univ. of Kansas, Lawrence.* *Received 21 June 1960.*

HOMING IN THE EASTERN CHIPMUNK

A definite homing ability in the eastern chipmunk, *Tamias striatus*, has been recorded by several investigators. Seton (Lives of Game Animals, 1929) and Burt (Misc. Publ. Mus. Zool., Univ. Mich., No. 45, 1940) had chipmunks return to the original site of capture after being transported 150 yards distant. Regular feeding trips of 400 paces from the den were made by one chipmunk (Allen, Bull. N. Y. State Mus., No. 314, 1938). Smith (Unpubl. Ph.D. dissertation, Cornell Univ., 1942) had three chipmunks return to the original point of capture after being removed 650, 700 and 900 feet, respectively. Some have returned relatively long distances within a 24-hour period: 350 and 500 paces (Allen, *op. cit.*) and 165 to 306 feet (Manville, Misc. Publ. Mus. Zool., Univ. Mich., No. 73, 1949).

All of the unrecovered animals studied during homing experiments by Smith (*op. cit.*) were juveniles. He concluded from this that the "instinct" to return home is weakly developed in young animals. Extensive movements in chipmunks are believed to be confined chiefly to juveniles and adult males (Burt, *op. cit.*).

Fifty-four chipmunks (*T. s. lysteri*) were subjected to homing experiments in 1958 and 1959 on the Cornell University campus in central New York. The terrain, consisting of wooded slopes, necessitated pacing the distances involved and, therefore, the distance figures in feet are approximate.

Of 24 juveniles (50% males) transported distances of 495 to 1,425 feet from their home site, only two males (8.3%) returned. One returned 645 feet consistently in three trials.

This one was recovered three days, two days, and one day, respectively, after release. The other male returned 705 feet in less than one day.

Seven subadults (animals nearly or completely full-grown in their first year but not sexually mature) were tested; six of them were males. They were transported distances ranging from 480 to 1,800 feet and four returned. Three males returned distances of 480, 645 and 1,800 feet and were recovered in 12, 2 and 17 days, respectively. The one female returned a distance of 795 feet in 11 days or less.

Twenty-three adult chipmunks were tested; 12 (52.2%) of them were males. Distances ranged from 150 to 1,800 feet and the number of female returns was greater than the number of male returns (15 and 12, respectively). Of two males and one female transported 1,800 feet, only the female returned. She was recaptured 16 days after release. A male returned a distance of 1,500 feet in five days or less.

From these data it appears that juveniles are not as capable of homing after removal as are adults; however, this may simply indicate a greater instinctive tendency in the young to disperse for self-preservation. Smith's conclusions (*op. cit.*) may be untenable since the possibility exists that a stronger "drive" (dispersal) takes precedence over the less dominant one (homing) in the juvenile chipmunk. Since the female returns were numerically greater than those of the males, especially when the longer distances were involved, a greater propensity in females to "home" may be indicated.—D. R. Seidel, *Conservation Dept., Cornell Univ., Ithaca, N. Y. Received 7 July 1960.*

CALIFORNIA GROUND SQUIRREL INVADES WASHINGTON

About 45 years ago California ground squirrels, *Citellus beecheyi douglasi*, entered the state of Washington from the south. The first immigrants crossed the Columbia River near The Dalles, Oregon, and became established by 1915 on the north side of the river at White Salmon, Klickitat County (Scheffer and Dalquest, Murrelet, 20: 44, 1939). The colony prospered. Since then the species has spread northward with great success. Thirty-three years later, Dalquest (Univ. Kansas Publ., Mus. Nat. Hist., 2: 276, 1948) found California ground squirrels northeast as far as Goldendale. By 1954 they had spread about 21 miles further east and 20 miles north of Goldendale. The squirrels had moved over the crest of the oak and pine-clad mountains at Satus Pass, about 6 miles down Satus Creek on slopes leading into Yakima Valley (Clanton and Johnson, Murrelet, 35: 15, 1954; Broadbooks, J. Mamm., 39: 301, 1958). The species had spread about 48 miles ENE of White Salmon.

Citellus beecheyi now is to be found at a new locality—the Tieton River canyon, 75 miles NNE of the original point of entry into the state. At noon on 31 July 1959 I saw a large California ground squirrel on a rock near the highway about 1 mile east of the Tieton Ranger Station. A few minutes later another one ran across the road several miles further down the canyon. Walter Tocarczyk, forest ranger at the Tieton Ranger Station, told me he has seen California ground squirrels in the pasture by the station. He recalled that they have moved westward up the Tieton canyon about 3 miles in the last three years. Also he knew that they had moved down the canyon a little past the National Forest boundary, about 9 miles from the Ranger Station. A friend of Tocarczyk told him that he had seen these squirrels about ½ mile north of the Tieton River up the Bear Canyon road. Oaks and rocky terrain occur there. Tocarczyk has not seen the species any farther north than this up the Naches and Rattlesnake River canyons.

The ranger station, 3 miles east of Rimrock and the Tieton Reservoir in northern Yakima County, is the westernmost record for the ground squirrels in this area. There the mountain slopes are covered by yellow pines, and rise from 2,450 feet at the canyon floor to a height of 6,000 feet. Only a few miles down the Tieton canyon the woods give way to grass-covered basaltic ridges. This sort of foothill habitat probably is occupied by the California ground squirrel all along the Cascade Mountains south of the Tieton River to the Columbia.

Tocarczyk has in fact seen the ground squirrels in the Ahtanum Creek area some 15 miles south of the Tieton. He says they are abundant 3 miles northwest of Tampico, having increased in numbers during the three years he has visited that area.

East of the Cascade range the rate of advance until now has averaged about 1.5 miles a year. Undoubtedly this expansion will continue along the foothills toward Canada.

At the moment the California ground squirrels appear to be entering a previously unoccupied habitat in the foothills between the two resident species, *Citellus lateralis* and *Citellus townsendi*. The golden-mantled ground squirrel, *C. lateralis*, is abundant on the eastern slopes of the Cascade Mountains, ranging from the crest down to the lower border of the yellow pine forest. Perhaps the golden-mantled ground squirrel and California ground squirrel meet all along the base of the mountains as far south as the Columbia River. Since the two species have just come into contact at the Tieton Ranger Station, this would be a good place to observe the interaction and possible competition between them.

At present there are no obvious physical or biological barriers to further expansion for a considerable distance in favorable habitat along a corridor running between the Cascade Mountains and Columbia River into northern and northeastern Washington.—HAROLD E. BROADBOOKS, *Southern Illinois Univ., Alton.* *Received 31 August 1960.*

A POCKET GOPHER POPULATION CRASH

The population density of pocket gophers, *Thomomys bottae bottae*, was observed to crash in 1959 throughout about 1,000 acres of improved rangeland (both dry and irrigated permanent pastures for cattle) on the Pomponio Ranch near San Gregorio, San Mateo County, California. Fortunately, the relative abundance of gophers had been determined, by methods described below, in ten of the pastures (about 90 acres) both prior to and following the sudden crash (Table 1). The sudden population decline occurred sometime between the summer and winter of 1959, but at slightly different times in different fields.

The relative density figures in Table 1 were obtained in two ways: (1) by observing the distribution patterns of recently formed gopher mounds, which the author's experience in live-trapping gophers has shown provides a fairly good estimate of the number of individually occupied gopher systems; and (2) by transect counts of fresh gopher workings. Each transect, which should be at least 1,000 feet long, was paced off with one hand-tally counter. Simultaneously, another counter was used to record each fresh gopher mound intercepted in the 20-foot-wide transect (10 feet wide when stands of herbaceous vegetation are dense). With the transect method, each time a fresh mound is intercepted, no more mounds are counted until the recorder has moved an additional 5 yards. By converting the area of the transect into acres, the number of mound counts then represents the approximate number of pocket gophers per acreage included in the transect. With both census methods, the counts are made during or shortly after a period of considerable digging by gophers.

Instead of trying to estimate the density of the gopher population by live-trapping and marking all individuals, which is an impossible feat with pocket gophers and most other species of rodents in an area as large as 90 acres, only an approximation of the exact density was obtained. However, since the two methods used were always repeated in an identical manner, they provide a reliable relative index of the degree of change that occurred during the crash of 1959. And, fortunately, pocket gophers have fairly fixed and permanent homesites and their presence is readily apparent from the fresh mounds of earth they form on the surface following fall and spring rains. In a sizable area, a light to moderately dense population of gophers can be more readily censused by observing the patterns of fresh mounds following an irrigation or several inches of rain, than can a population such as *Peromyscus* by either snap or live traps. On the other hand, it is not satisfactory to use this method with dense populations of gophers. When the density

TABLE 1.—*Density of pocket gophers in 10 pastures in San Mateo County, California, before and after a sudden, unexplained decline in numbers*

Pastures:	A	B	C	D	E	F*	G	H	I	J*
Acres:	9.1	4.0	19.0	11.5	8.6	4.4	5.1	5.4	13.0	8.8
	Gophers per acre (total number of gophers estimated from pattern of gopher mounds)									
11–17 Feb. 58	21 (187)	23 (90)	–	–	–	–	–	–	–	–
4–6 Mar. 58	–	–	10 (189)	13 (154)	17 (147)	30 (133)	–	–	–	–
14–16 Apr. 58	–	–	–	–	–	–	23 (115)	22 (121)	15 (193)	–
26 Feb. 60	2 (18)	3 (7)	2 (30)	2 (18)	4 (31)	13 (57)	3 (15)	3 (16)	1 (15)	–
% reduction, 1958 to 1960	90	92	84	88	79	57	87	87	92	–
Acres per transect:	.59	.44	1.03	.86	.80	1.24	.62	.71	1.54	.79
	Gophers per acre (total number of gopher mounds counted in transects)									
9–13 Feb. 59	17 (10)	21 (9)	30 (31)	58 (50)	61 (49)	36 (44)	47 (29)	32 (23)	14 (21)	62 (49)
27 Oct. 59	15 (9)	16 (7)	13 (13)	6 (5)	14 (11)	7 (9)	–	–	–	6 (5)
11 Feb. 60	2 (1)	2 (1)	4 (4)	6 (5)	9 (7)	11 (14)	10 (8)	11 (8)	1 (1)	9 (7)
26 Feb. 60	2 (1)	2 (1)	2 (2)	7 (6)	10 (8)	14 (17)	6 (4)	8 (6)	4 (6)	–
% reduction, 1959 to 1960	90	89	87	90	86	68	72	65	95	86

* Irrigated.

approaches 50 or more gophers per acre, the transect count becomes more reliable than the total count.

When an attempt was made to recount the entire population of gophers in nine of the ten fields in the spring of 1960, in the same way as was done in the spring two years earlier, the results indicated a decline in gophers from 1,329 in 1958 to 207 in 1960, or a loss of 84 per cent (ranging from 57 to 92 per cent in each field). By means of transect counts made in the spring of 1959, and repeated exactly one year later, the reduction of gophers ranged from 65 to 95 per cent in the ten fields, averaging an over-all loss of 82 per cent. This compares favorably with the 84 per cent decline determined by the total count method.

Prior to May 1958, various kinds of gopher control had failed in all 10 pastures and, in November 1958, all pastures had a high population of gophers. Fields *A* and *F* were the only pastures that received any treatment after April 1958. A number of gophers were poisoned in Field *A* with a commercial gopher bait (Gopher Tabs) in February 1959, and a few gophers were periodically trapped in Field *F* throughout 1959. Most of pastures *F* and *J* were irrigated by sprinkler; the other pastures are all much too hilly for irrigation. The main dryland species of vegetation present are hardinggrass, alta fescue, narrowleaf birdsfoot trefoil, and perennial ryegrass, with bur clover and filaree coming in naturally. The predominant species on the irrigated pastures (*F* and *J*) are ladino clover, narrowleaf birdsfoot trefoil, orchardgrass and fescue.

Before the crash, some of the pocket gopher populations were so dense that they seriously damaged the stand of perennial forage and cut the forage yield about in half. The sudden decline in gophers was general throughout the area, occurring on summer-grazed areas, on fields being held for winter grazing, and on irrigated pastures, regardless of whether there had been any recent gopher control activities with traps or poisons.

The crash seemed to occur irrespective of the density of gophers present, but intraspecific competition (stress) might in some way have been a contributing factor. A drought in 1959 was at first thought to be a factor, but gophers also declined in the irrigated pastures where there was no shortage of forage or moisture. Inadequate food cannot be the explanation. Unfortunately, nothing is known about the presence or absence of diseases.

This is the most dramatic, rapid fluctuation in pocket gopher densities known to the author. In one intensive, live-trapping study of *Thomomys bottae mewa*, by Howard and Childs (Hilgardia, 29: 277–358, 1959) the density of a "stable" population of gophers on a 4-acre plot fluctuated as much as 50 per cent, but the change was gradual, taking four years.—WALTER E. HOWARD, *Field Station Administration, Univ. of California, Davis.* *Received 2 May 1960.*

SEEDS STORED BY PRAIRIE DEER MICE

The feeding habits of small rodents can be determined from examining cheek pouch and stomach contents, feces, and field signs, and from feeding tests with caged animals. Present information indicates that food habits depend largely on specific and individual preferences and on what is available. This report deals principally with the amount and kind of seeds stored by prairie deer mice, *Peromyscus maniculatus bairdii*, in artificial nest boxes, although some information is based on field signs—items that the animals did not cache but carried into the shelter of a nest box before eating (Table 1). Additional data were obtained on the time of year when the various food items were stored and eaten, and on the number of mice involved in the family aggregations living in the boxes containing the food caches.

On the Edwin S. George Reserve, Pinckney, Livingston County, Michigan, 136 small mammal nest boxes were distributed over about 300 acres of grassland, bordered mostly by oak–hickory woods (Howard, Univ. Mich. Contrib. Lab. Vert. Biol., No. 43, 50 pp., 1949). The physiography and vegetation of some of these grassland areas have been described by Blair (Amer. Midl. Nat., 24: 273–305, 1940), Evans and Cain (Univ. Mich.

Contrib. Lab. Vert. Biol., No. 51, 17 pp., 1952), and Evans and Dahl (Ecology, 36: 685–706, 1955). On the Reserve, the prairie deer mouse is restricted to grasslands; it has never been taken in any of the wooded tracts.

All but 23 of the nest boxes were partially buried; they were used as shelters not only by prairie deer mice but also by other small mammals, snakes, salamanders and bumblebees. A total of 155 food stores were collected or recorded from 54 nest boxes occupied by prairie deer mice between 1 November 1940 and 12 October 1942, while the senior author was working under the direction of L. R. Dice at the Laboratory of Vertebrate Biology, University of Michigan, Ann Arbor. The seeds were identified by the junior author. I. J. Cantrall made available a list of flowering plants known to occur on the Reserve.

By volume of seed stored, only four kinds of plants were really important: ragweed (*Ambrosia artemisiifolia*), oaks (*Quercus velutina*, *Q. alba* and *Q. borealis*), bush clover (*Lespedeza capitata*), and panic grass (*Panicum*, probably chiefly *P. oligosanthes* var. *Scribnerianum*) (Table 1). Sometimes, however, many plant species were represented in a single cache. One family of mice had included nine species of plants in their food store, although ragweed made up most of the volume. Other items in the food caches were remains of grasshoppers, beetles, other insects, deer pellets, a fox scat, a few leaves in most boxes, flower parts, and lichens. Different weed seeds were often piled separately, perhaps because foraging mice concentrate on one species at a time.

The amount of seed stored varied greatly. More than 20 cc of weed seeds, or at least 10 acorns or cherry pits (*Prunus*, almost certainly *P. serotina*), were found in 71 of the 155 food stores. An extra-large nest box contained the largest cache: an accumulation in less than one month of 1,050 cc of weed seeds (mostly ragweed), 565 acorns, and six deer pellets. The oak tree nearest to this box was 120 feet away. Seven or eight mice apparently contributed to this cache; on 27 November 1941, when it was completed, 12 mice were present, of which 5 were dead young. In another box, five deer mice piled up

TABLE 1.—*Food items of prairie deer mice found in nest boxes on the E. S. George Reserve, Livingston Co., Michigan*

ORDER OF OCCURRENCE	FOOD ITEMS	PRESENT IN NUMBER OF BOXES	ORDER BY VOLUME
1	*Ambrosia artemisiifolia*, ragweed	36	1
2	*Panicum oligosanthes* ?, panic grass	28	4
3	*Lespedeza capitata*, bush clover	26	3
4	*Prunus serotina* ?, cherry	17	5
5	*Quercus velutina, alba* and *borealis*, oak	11	2
6	*Aristida purpurascens*, triple-awned grass	9	6
6	*Desmodium illinoiense*, tick trefoil	9	8
7	*Rumex Acetosella*, sorrel	8	7
8	*Asclepias syriaca*, milkweed	7	9
9	*Cenchrus* ? *longispinus*, sandbur	4	10
9	Other *Gramineae*, grasses	4	12
10	*Polygonum* ? *tenue*, knotweed	3	12
10	*Polygonum convolvulus*, black bindweed	3	13
10	*Liatris aspera*, button snakeroot	3	13
10	*Carya*, hickory	3	14
11	Other *Leguminosae*, legumes	2	11

1,300 cc of seeds, mostly of ragweed, although some of panic grass were included. In a third box, seven mice cached 800 cc of seeds, largely ragweed, but with some bush clover, panic grass and cherry pits. Other large caches had weed seeds in the following amounts: 650, 550, 550, 500, 450, 350, 300, 250, 200 and 200 cc. The largest numbers of acorns found were: 565, 285, 225, 200, 200 and 157. Most of these boxes were some distance from oak trees.

The deer mice began storing food in about the middle of October. Seed storage in the nest boxes was maximum in late November. Some of panic grass appeared in boxes in July, and a few cherry pits were present in September. In October, there were seeds of bush clover, ragweed, tick trefoil (*Desmodium illinoiense*), triple-awned grass (*Aristida purpurascens*), and an unidentified legume. Seeds in November included lots of ragweed and some sandbur (*Cenchrus ? longispinus*), sorrel (*Rumex Acetosella*), and acorns. Most of the acorns were cached in December. Much of the stored food was gone by the end of December, and all had disappeared by March.

Food items were observed for white-footed mice, *Peromyscus leucopus noveboracensis*, living in 13 nest boxes. In six boxes were hickory (*Carya* spp.); in three, acorns; in three, bush clover seeds; in two, cherry pits; in one, seeds of panic grass. In one nest box inhabited by two wood mice was a salamander (*Ambystoma*), most of which they consumed in 16 days.

From a study of small mammal populations at the Rose Lake Wildlife Experiment Station, Clinton County, Michigan, Linduska (Mich. Dept. Conserv. Game Div., 144 pp., 1950), listed the contents of three prairie deer mouse food caches—one of 80 cc collected from an artificial nest box, and two found during excavation of woodchuck dens. Of the ten species of weed seeds found, eight were in the list of the ten most common weed seeds reported for the area by Baumgras (J. Wildl. Mgmt., 7: 13–18, 1943), who estimated a density of 211.5 pounds of weed seed per acre on wheat stubble (the most productive farmland habitat studied) in October 1940. Ragweed (*Ambrosia elatior, A. artemisiifolia*) and lamb's quarters (*Chenopodium album*), the two most plentiful species in many parts of the study area, were the two species found in greatest volumes in Linduska's caches, although only ragweed was present in all three caches.

The contents of eight prairie deer mouse caches found in Manitoba were reported by Criddle (Canad. Field-Nat., 64: 169–177, 1950). Analysis of his data indicates great variability from cache to cache, and points to availability as a prime factor in determining the kinds of seeds stored. The principal kinds of seeds found in the caches in the eight different habitats, by per cent of total weight, were acorns (100 per cent) in cache in oak grove, cherry stones (95.4) in cache among cherry bushes, wheat (71.0) in straw stack by granary, wheat (63.5) in wheat stubble, wheat (49.2) in drill grain box 127 yards from granary, knotweed (45.7) in pasture, rye (36.5) and wild buckwheat (31.3) in rye field, and wheat (29.7) and sweet clover (26.4) in cache in sweet clover field. Williams (J. Mamm., 40: 415–419, 1959) examined the contents of 122 deer mouse stomachs and found that the starchy interiors and integuments of seeds made up two-thirds to three-quarters of the material present.

Cogshall (J. Mamm., 9: 217–221, 1928) used caged animals to ascertain the kinds of food eaten by prairie deer mice, white-footed mice, and Sonoran deer mice, *Peromyscus maniculatus sonoriensis*. The mice were maintained with an excess of laboratory diet at all times and were offered a great variety of seeds, fruits, nuts, buds, bark, bulbs, insects, crayfish, earthworms, and frog and salamander eggs. Almost everything provided was eaten; there were no marked differences in acceptance among the three kinds of mice, although sprouting grains and bulbs were eaten especially readily by prairie deer mice. Considerable storage was noted, particularly of nuts.

The habit of storing large quantities of food even when it is consistently plentiful was observed by the junior author also in a population of prairie deer mice maintained in 1955 and 1956 in an outdoor enclosure at the Laboratory of Vertebrate Biology. The mice were

provided with abundant supplies of a diet including a mixture of wheat, hemp and millet seeds. Large stores of the seeds, in one case almost completely filling an 8×8×8-in. nest box, were built up at all times of the year; these were emptied occasionally, but more often were abandoned to mold and decay. Each kind of seed was apparently cached separately; some of the stores consisted of a single kind of seed, others included piles of several kinds.—Walter E. Howard, *Field Station Administration, Univ. of California, Davis,* and Francis C. Evans, *Dept. of Zoology, Univ. of Michigan, Ann Arbor.* *Received 6 June 1960.*

VOICE OF THE GRASSHOPPER MOUSE

Vernon Bailey (N. Amer. Fauna 53: 136, 1931) described the voice of the grasshopper mouse, *Onychomys*, as ". . . a fine shrill whistle or prolonged squeak, insectlike in attenuated quality but as smooth and prolonged as the hunting call of the timber wolf . . . ," and again (p. 137) as ". . . a prolonged note so thin and piercing that its vibrations must have been about the limit of rapidity to which human ears are attuned." A better description of the call of this little mouse would be difficult to offer, but the entire description is essential. It is inadequate to liken the call simply to that of "a miniature wolf," as is done by each of the "regional" mammal reports in my library that mentions the voice of *Onychomys* at all. Bailey likened it to the call of the wolf only in its qualities of smoothness and prolongation, and in the posture of the animal as the call is uttered. Young and Goldman (The Wolves of North America, Amer. Wildlife Inst., 1944), in describing five wolf sounds, use adjectives such as "loud," "throaty," "deep," and "guttural." Thus, the squeak of *Onychomys* should be defined more precisely—particularly since its call has been compared to those of *Reithrodontomys* (Svihla, J. Mamm., 17: 172, 1936) and of *Baiomys* (Blair, J. Mamm., 22: 378, 1941).

A single typical call of a captive *Onychomys leucogaster*, recorded on tape, was played into an oscillograph, and the screen was photographed. The sound wave is nearly, but not exactly, a sine curve, and the frequency is 10,000 vibrations per second. This note can be heard by most human ears but has twice the frequency of the highest fundamental note of the piccolo. Despite its "smooth and prolonged" quality, it is easily distinguished from the howl of a wolf.—Milton Hildebrand, *Dept. of Zoology, Univ. of California, Davis.* *Received 31 May 1960.*

CLETHRIONOMYS AND *PEROMYSCUS* IN SOUTHEASTERN MASSACHUSETTS

Observations were made of the incidence of red-backed voles, *Clethrionomys gapperi*, and white-footed mice, *Peromyscus leucopus*, in four different habitats in Raynham, Bristol County, Massachusetts, over a ten-week period (7 July to 10 September 1959). This study was made possible by Dr. Richard O. Hayes, Communicable Disease Center, U. S. Public Health Service, and Dr. F. Randolf Philbrook of the Massachusetts Department of Public Health, and was conducted in conjunction with a study of eastern encephalitis sponsored jointly by the two agencies represented.

Modified Scheffer traps (Davis, *Manual for analysis of rodent populations*, 1956, pp. 3–16) were set in a grid consisting of seven rows of seven tiers in each study area and baited with varying mixtures of canned dog food, peanut butter, and rolled oats. Trap distances varied from 25 to 50 feet, depending on the physiography of the study area. Each study area was trapped a total of 735 trap-nights, and mice and voles captured were sexed, aged, weighed, bled via a cardiac puncture no oftener than every 30 days, and marked by toe clipping.

Locations of study areas are indicated in Fig. 1. Site 1 is in a mature swamp typical of coastal areas of Massachusetts, white cedar (*Chamaecyparis thyoides*) grading into red maple (*Acer rubrum*) at the periphery. Site 2 is in a 15-year-old old field succession, sheep laurel (*Kalmia angustifolia*) and blueberry (*Vaccinium* spp.) grading into red maple and

TABLE 1.—*Summary of trapping data for the four study areas*

Species	Site 1		Site 2		Site 3		Site 4	
	♂	♀	♂	♀	♂	♀	♂	♀
Peromyscus	5	6	7	3	9	6	9	7
leucopus	(5)*	(6)	(5)	(2)	(9)	(4)	(7)	(7)
Clethrionomys	4	2	1	1	6	2	5	2
gapperi	(3)	(2)		(1)	(5)	(2)	(4)	(2)

* Animals produced during spring and summer of 1959 indicated in parentheses.

white pine (*Pinus strobus*). Site 3 borders a small river. The frequently flooded bank area has no large trees, but the adjacent elevated area is dominated by red maple and black cherry (*Prunus serotina*). Site 4, a fairly mature 30-year-old old field succession, is dominated by white pine, red maple, and black oak (*Quercus velutina*).

Trapping data are summarized in Table 1. Individuals of *Peromyscus* outnumbered those of *Clethrionomys* by more than 2 : 1. More than 80 per cent of the mice and voles were born during the spring or summer of 1959. Males of *Peromyscus* outnumbered females 3 : 2, and twice as many male as female voles were captured. Fifty per cent more individuals of *Peromyscus* were taken in Sites 3 and 4 than in Sites 1 and 2. Individuals of *Clethrionomys* were about equally abundant in Sites 1, 3 and 4, but only two were captured in Site 2. In the four study areas individuals of *Peromyscus* were apparently more numerous per unit area than those of *Clethrionomys*, and they moved more frequently and over greater distances. Most of the mice and voles were apparently resident within the study areas.

Individuals of *Peromyscus* and *Clethrionomys* were not taken in Site 1 until most of the standing water had left the grid and it was connected to adjacent upland. Throughout the trapping period they were most numerous near the periphery, where red maple is dominant. In Sites 2 and 3 neither mice nor voles were taken in open fields. In Site 3 they were most abundant in the elevated zone where stumps and fallen trees are numerous. In Site 4 individuals of *Clethrionomys* were restricted to the eastern third of the grid.

There appeared to be a correlation between numbers of both species captured. During periods of heavy rain, lower temperatures and high humidity, catches were reduced. It is probable that heavy rain was the main inhibiting factor.

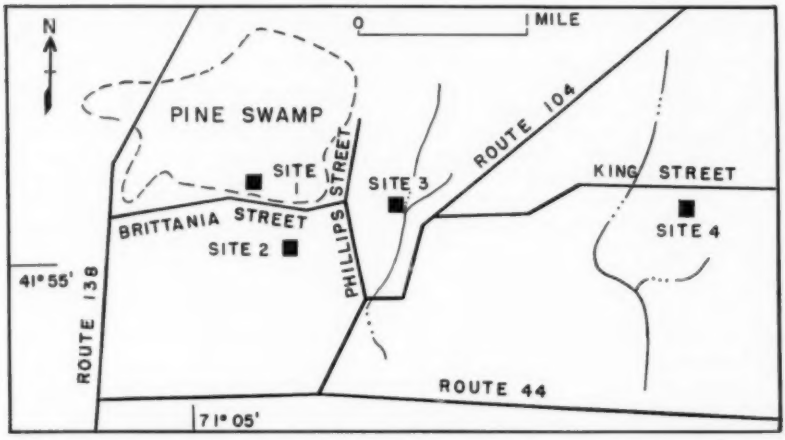

FIG. 1.—Diagrammatic map with location of the four study areas. (*After U.S.G.S., 1944.*)

While the period of trapping was too short and the captures too few to contribute anything really new to the knowledge of rodent populations and behavior, certain aspects of the data are worthy of note. This is the first study of this sort of either species in this area, and the first study of small mammals in a coastal Massachusetts cedar swamp. The data indicate that *Peromyscus* is nearly ubiquitous in this area, while *Clethrionomys* is not. The requirements for *Clethrionomys* in this area are apparently similar to those for the same species in Minnesota (Gunderson, J. Mamm., 40: 405–412, 1959). However, the relative abundance of *Clethrionomys* in Site 4, where the nearest water is at least 200 yards away, seems to contradict the conclusion of Odum (J. Mamm., 25: 404–405, 1944) that this species is largely dependent on water available in the habitat. This, and the peculiar distribution of this species in Site 4, remain unexplained.

Apparently both open water and open fields serve as a barrier to movements of both species. Predation may have been a factor with the latter. Black racers (*Coluber constrictor*) were found adjacent to Sites 2 and 3 in the open fields, and owl pellets were found in Site 2. Individuals of both species will move into a cedar swamp as it dries out in the summer. These probably are mostly young of the year moving out in response to population pressures.

According to Hall and Kelson (*The mammals of North America*, vol. 2, 1959), *Clethrionomys gapperi ochraceous* (Miller) is the subspecies in southeastern Massachusetts. My specimens more closely resembled typical *Clethrionomys g. gapperi* (Vigors). A comparative taxonomic study will be forthcoming.—JOSEPH H. WATERS, *Dept. of Biology, Bridgewater State Coll., Bridgewater, Mass.* *Received 24 August 1960.*

COTTON RAT MORTALITY DURING SEVERE WINTER

Four dead cotton rats, *Sigmodon hispidus komareki*, were found on 8 March 1960 in a nest box on the radioactive White Oak Lake bed study area No. 3 (WOL-3) after a particularly cold period. White Oak Lake was a 44-acre impoundment which served as a final settling basin for radioactive wastes until it was drained in 1955. The lake bed has been a site for ecological studies at Oak Ridge National Laboratory, Tennessee, since 1956 (Auerbach *et al.*, 1957–1959). Plant succession has proceeded at a rapid rate and the area now has thick growths of sedges, rushes, willows and other vegetation. Long-term studies on field populations of small mammals began in 1958. Data are accrued mainly by a routine capture–recapture live-trapping procedure.

Three of the rats died huddled side by side with their heads close together (Plate I) but the position of the fourth rat indicated that he may have died while trying to force his way under the others. The exact times of death are not known but, judging by the condition of the bodies and considering the weather, the rats had not been dead for more than a few days. Six live cotton rats were found in the nest box 12 days previously; two of these were caught and one was in the group of dead *Sigmodon* found on 8 March.

The four dead rats were No. 282, ♂, 231–90–30.5 mm, 73.0 gm; No. 286, ♀, 221–82–30.5, 59.0; No. 358, ♂, 247–102–31, 85.5; and an unmarked individual, ♀, 195–79–29, 53.5. Of the four individuals, No. 358 was one of the two rats captured in the nest box on 24 February and had been first captured on 10 December 1959. Numbers 282 and 286 were first taken on 16 September 1959 from a natural nest containing three other young, but neither was recaptured until 3 February, when No. 282 was trapped. Apparently Nos. 282 and 286 left the study area shortly after they were able to shift for themselves but returned several months later.

Trapping records show that weights of all cotton rats dropped sharply during the winter. Of the four dead rats, two had been caught earlier during the winter. On 10 December, No. 358 weighed 115 gm; on 24 February, 98; and on 8 March, 85.5. Number 282 weighed 97 gm on 3 February and 73 gm on 8 March. Desiccation after death was

probably negligible because temperatures did not rise above 36°F for the six days preceding discovery of the dead *Sigmodon*. Very little fat was evident in the bodies. On the same day that the dead rats were discovered, a live *Sigmodon* was found in the cotton of an unset trap (traps are locked open when not in use). This individual weighed 85 gm; on 24 February it had weighed 101 gm. Of nine cotton rats examined on 24 February, seven had been captured within a 3-month period prior to that date. The average weight loss of these seven individuals from date of last capture was 14.3% of body weight with extremes of 5.1 and 25.0%. A similar pattern of weight loss was present during the winter of 1958–1959.

Another dead cotton rat was found in an unset trap on 22 March in the WOL-3 area. This animal, an unmarked young adult male, was too decomposed for accurate measurements and weight to be taken. On 23 March, bits of *Sigmodon* fur and bones were found in two unset traps in a nonradioactive old-field study area (OF-1) about 1 mile from WOL-3. Routine trappings in the WOL-3 and OF-1 areas during the latter part of March and during April revealed that the resident cotton rat populations had vanished from both areas. However, a specimen was snap-trapped on 6 April in a thick growth of Japanese honeysuckle (*Lonicera japonica*) near the lake bed. The honeysuckle is evergreen in this

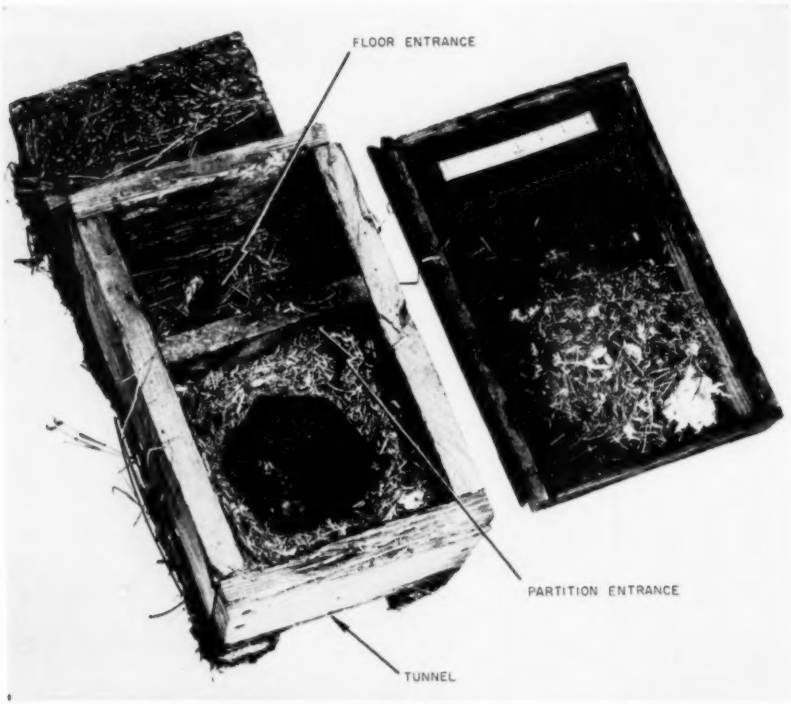

PLATE I

Dead cotton rats in nest box; top of nest lifted off and loose pieces brushed from rats. Nest compartment is filled with dry plant material (mostly stems and leaves of rush, sedge and grass) and small pieces of cotton pilfered from trap-nesting material used during cold-weather trapping.

region and thick mats effectively prevent snow from covering the ground. An unmarked rat was taken in an unset trap on the WOL-3 area on 14 April. Since these captures, no *Sigmodon* have been caught to the present time (July 1960) although several likely places in the Oak Ridge area have been thoroughly trapped.

The winter of 1959–1960 was severe for this region. The Oak Ridge Weather Bureau report for February states, "Greatest monthly and seasonal snowfall of record." Over 43 in. of snow were recorded from 1 January through March. The report for March noted, "Coldest March, heaviest monthly snowfall on record." At a class "A" weather station on White Oak Lake bed the minimum temperatures for 1–8 March were 20, 26, 23, 13, 0, 0, 14 and 6°F, respectively.

Huddling of mammals for warmth is a common occurrence and has the effect of reducing exposed surface in relation to volume (Pearson, 1947). No "mother and family" relationship existed among the five individuals captured or found dead in the nest box on WOL-3 so that this was not a "great family" aggregation as described by Frank (1957) for *Microtus arvalis* during winter. In spite of the advantages afforded by huddling in the large dry nest enclosed by the box and although the gastrointestinal tract and contents averaged 2.4 gm (dry weight), it may be that the quantity and/or quality of food were insufficient to maintain necessary metabolic functions, and the four cotton rats may have fallen victim to what has been termed "cold weather starvation" by Howard (1951). Large losses in the weights of cotton rats during the last parts of the winters of 1958–1959 and 1959–1960 certainly indicated that serious demands were being imposed on vital processes of the individuals. Decreasing food, continuing heavy demands for heat production, and diminishing fat reserves were probably major factors contributing to this weight-loss phenomenon.

Sigmodon hispidus texianus has pushed as far north as Nebraska (Jones, 1960). Cockrum (1948) estimated that in Kansas this subspecies extended its range about 100 miles northward from 1933 to 1947. He noted also that after a particularly severe winter in 1948–1949, during which ice and sleet covered the ground for about a month, the cotton rat populations were low, and he speculated that severe winters might be important in slowing the northward advance of *S. h. texianus* (Cockrum, 1952). Cotton rats in the Oak Ridge area are near the northern limits as drawn by Hall and Kelson (1959) for this vicinity. The species was present near Knoxville, Tennessee (about 16 miles east of the Oak Ridge area) in 1951 (Howell, 1954). Although it is unlikely that *S. h. komareki* was completely exterminated in this part of its geographic range during the rigorous winter of 1959–1960, the populations were eradicated in those areas under study at Oak Ridge.—Paul B. Dunaway and Stephen V. Kaye.

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VIRGINIA MUSKRAT IN SOUTHEASTERN NORTH CAROLINA

The range of the muskrat, *Ondatra zibethicus*, on the North Carolina coast is generally restricted to the area north of Pamlico Sound (Miller and Kellogg, U. S. Nat. Mus. Bull. 205: 615, 1955). However, while seemingly absent from most of the area south and east of the Neuse River, the muskrat is present in some numbers in the lower Cape Fear drainage of southeastern North Carolina. I have seen muskrats and their characteristic signs in ponds and tidal creeks in Brunswick, New Hanover, Onslow, and Pender counties. These animals live almost entirely in bank dens. I have never seen a muskrat "house" in these counties. While collecting reptiles and amphibians with a headlamp, I have seen 12 to 15 muskrats in one evening in Smith Creek, in New Hanover County. All specimens I have handled have been the subspecies *macrodon*.

Prior to 1950 muskrats were uncommon, but in the past decade they have increased in number and spread to many lakes and ponds previously unoccupied. A factor influencing this trend has been the virtual retirement of the only professional trapper in the region. Even before this, however, he no longer made drown sets for muskrats in the tidal creeks, where they are most common, because of a marked increase in the numbers of the blue crab, *Callinectes sapidus*, in the area. These crabs almost invariably ruined the pelt if the trapped animal remained in the water for a few hours.—JOHN B. FUNDERBURG, *Dept. of Zoology, Duke Univ., Durham, North Carolina. Received 6 April 1960.*

MELANISTIC NORWAY RATS IN SOUTHERN CALIFORNIA

There are few natural occurrences of melanistic Norway rats, *Rattus norvegicus*, recorded in recent literature. The latest of these concerns 100 melanistic Norway rats captured in four counties of southeastern Georgia (Smith, J. Mamm., 39: 304–306, 1958).

This note reports the collection of five melanistic Norway rats, three females and two males, from a small section of the sanitary sewers of Pasadena, California, between 6 May 1959 and 20 January 1960. All of the rats were live-trapped in Havahart cage traps.

One female gave birth to five young the day after capture. One unidentified and hairless individual died and was eaten by the mother on the sixth day; the rest of the litter, one female and three males, were melanistic. The mother and the young were sacrificed at various ages and mounted as study skins.

A survey of 510 sewer manholes in Pasadena and the surrounding communities of Altadena, San Marino and South Pasadena indicated that the population under discussion is isolated, for with this one exception sewer rat activity was at a very low level with light infestations occurring only at widely scattered points. Rat traps set in selected structures near the points of melanistic rat captures produced no further rats, thus indicating the melanistic rats are confined to the sewers and do not ordinarily appear above ground.

Since it has been noted that melanism in Norway rats acts as a simple Mendelian recessive character (Keeler and King, Anat. Rec., 81: 48–49, 1941), the all-melanistic litter and the apparent isolation of the population give some weight to the supposition that these individuals came from a true breeding melanistic population. However, this supposition can only be considered as an opinion until further study and more extensive sampling provides substantiating documentation.—DONALD L. ROHE, *California State Dept. of Public Health, Bureau of Vector Control, Los Angeles. Received 22 July 1960.*

STEREOTYPED FEEDING BEHAVIOR OF A NORTH CAROLINA NUTRIA

In July 1959, I made detailed observations on the feeding behavior of a nutria, *Myocaster coypus*, at Pea Island, Dare County, North Carolina. Although several recent papers have reported the nutria's food habits (e.g., Atwood, J. Wildl. Mgmt., 14: 249–265, 1950; Harris, Trans. N. Amer. Wildl. Conf., 21: 474–486, 1956), none describes details of feeding and associated behavior.

From 5:30 until 6:30 AM, on 11 July, I watched a nutria foraging in a shallow pool in which three-square (*Scirpus americanus*) was growing. In shallow water, the animal walked slowly, with its nose at water level and its tail dragging. In deeper water, it swam with its head up at a slight angle, its back barely breaking the water surface, and its tail floating on the water, apparently not used as a rudder.

As the nutria walked, it occasionally nuzzled stems and pulled them with its teeth. When an apparently suitable plant was chosen, the animal nuzzled it closely and then uprooted it immediately by pulling with its teeth or by digging at the roots with its forepaws. In digging, the paws are moved directly under the nose, either alternately or together, and the tail is held out stiffly behind. When a small pile of sand and mud accumulates under its body, the nutria stops digging and begins kicking the material to the rear with its hind feet, moving them alternately only. After clearing the pile, the nutria resumes excavating with its forepaws until the root is free. These stereotyped foraging motions were noted over 40 times.

When the root is exposed, the nutria pushes on the plant with one forepaw or its nose. This movement usually uproots the plant but, if it does not, the animal either severs the root by biting it, or excavates further. After the plant is free and lying horizontally, the nutria grasps it by slipping one forepaw under the root and laying the other forepaw on top of the stem. Then it bites the stem just above the root, and pushes down with the "stem" paw. At the same time, the "root" paw drops the severed root and grasps the stem base, so that the plant is positioned at the mouth, stem base foremost and the forepaws grasping either side. The stem is chewed with constant jaw motions, not individual bites. After stem base is eaten (sometimes up to several inches), it is dropped in place. These highly stereotyped feeding motions were seen over 35 times in a single 20-minute period.

The nutria's stereotyped feeding movements, like those of the coatimundi, *Nasua narica*, recently reported by Ingles (J. Mamm., 38: 263–264, 1957), are well adapted for its food. It would be interesting to learn if these motions develop autonomously (as the coati's apparently do) or whether they are formed largely through learning processes. If they are "instinctive," then the motions themselves may help to determine what kinds of food are eaten (i.e., stem bases of shallow water plants like *Scirpus americanus*).

Harris (*op. cit.*) reports that Louisiana nutria eat *Scirpus olneyi*, the principal food of the muskrat, *Ondatra zibethica*. Because of competition with the muskrat, and because it undermines banks by tunneling, the nutria should be controlled in some parts of its range. Atwood (*op. cit.*) has noted that nutria utilize logs as "feeding stations" when they forage in deep water; this is probably to free the forepaws for manipulating food as is done in shallow water.

John L. Sincock kindly confirmed some field identifications of plants from my color transparencies, and Thomas L. Quay read the manuscript in an earlier form.—JACK P. HAILMAN, *4401 Gladwyne Drive, Bethesda, Maryland.* *Received 13 June 1960.*

KOGIA STRANDED IN MARYLAND

The pigmy sperm whale or lesser cachalot, *Kogia breviceps* (Blainville), is regarded as a rare species; at least it has been reported infrequently, but this may be because it has been confused with porpoises. It is nearly cosmopolitan, occurring most commonly in warm seas, but has been reported from Nova Scotia, New Zealand and the Bering Sea (A. H. Clark, Smiths. Inst., War Background Studies No. 21: 54, 1945). The type locality

is off the Cape of Good Hope. Along the Atlantic Coast of the United States, 19 records from the waters of seven states were summarized by G. M. Allen (Publ. 511, Field Mus. Nat. Hist., Zool. Ser., 27: 17–36, 1941). Since Allen's paper, *Kogia* has been reported off South Carolina and New Jersey by Ulmer (J. Mamm., 22: 450–451, 1941), North Carolina by Brimley (*ibid.*, 26: 434, 1945), Georgia by Smalley (*ibid.*, 40: 452, 1959), and Florida by Moore (Amer. Midl. Nat., 49: 117–158, 1953). Herewith we report the first specimen recorded from Maryland waters.

About 10:00 AM on 9 August 1959 a "porpoise" (as reported by the local press) was stranded 4 miles north of Ocean City, Worcester Co., Maryland. Soon thereafter it was observed by the junior author, who obtained photographs which clearly indicate its identity. It was about 9 feet long, with a small falcate dorsal fin, and a small mandible, with many tiny teeth, well back from the blunt snout. The blowhole was distinctly left of center. It had a black back and sides, and whitish underparts suffused with pinkish. The animal was bleeding profusely from a puncture wound in the mid-abdomen and also from the anus. We speculate that the pinkish color was largely due to abrasions as the animal was buffeted about on the sandy beach.

Crowds soon gathered to view this curiosity. Attempting to assist it, several men launched it into deeper water, but the whale floundered about and circled back to shore again. This performance was repeated dozens of times and by 6:00 PM the whale had thus progressed from the latitude of 50th Street up to 80th Street. Apparently its efforts were hampered by a submerged bar. During the following night, with a high tide, the animal made its way back to deeper water and was not seen again. This episode has been reported to the Marine Mammals Committee of the Society.—RICHARD H. MANVILLE AND ROBERT P. SHANAHAN, *Bureau of Sport Fisheries and Wildlife, Washington 25, D. C. Received 3 June 1960.*

A SELF-TRAPPED GRAY FOX

This unusual circumstance of a gray fox, *Urocyon cinereoargenteus*, accidentally trapping itself was reported by Walter Albertsen. On 8 April 1957, he found a dead gray fox near the top of a flowering crab tree (*Malus* sp.) 18 to 20 feet high. There was a severe blizzard on the night of 5 April covering the apples on the ground.

The very tip of the tail was twisted in an S-shape around a forked branch and then through another forked branch. The distance from the crotch, where the tail was caught, to the ground was 14 feet. The fox had barked many branches within reach; smaller branches were chewed off and were either lying on the ground or were tangled in other branches.

The surprising thing to me was that the branches in the area where the fox had been feeding were quite small. None of them was more than about 2 cm in diameter. The gray fox must indeed be a skillful climber.—HARVEY L. GUNDERSON, *Museum of Natural History, Univ. of Minnesota, Minneapolis 14. Received 16 June 1960.*

ERYTHRISTIC RACCOONS FROM NORTH CAROLINA

There are few reports on erythrism in raccoons. Goldman (N. Amer. Fauna 60, 1950) recorded a specimen from Nelson County, Virginia, in which the black facial mask, post-auricular spots, dark bands on the tail, and dark tips of the hairs were light yellowish brown. Neill (J. Mamm., 34: 500, 1953) described two *Procyon l. elucus* from Marion County, Florida, in which the back was dull orange-red fading to ivory on the sides and belly, the facial mask burnt umber outlined with ivory, the tail rings golden brown, and the nose burnt umber.

During the 1946–1950 period, I was a professional taxidermist in Wilmington, North Carolina. Among 52 raccoons, *Procyon l. lotor*, received for mounting during this period

were five erythristic specimens and one complete albino. The erythristic animals were deep lemon yellow on the dorsum and sides, shading into pale lemon yellow on the venter. The facial mask, tail rings, and other normally black areas were a deep rust color. Neill (*ibid.*) stated only that the nose was burnt umber in his specimens, but in these five animals all soft parts were a light burnt umber. Eye color was normal in these animals. Collection data are as follows: (1) ad. ♂, 15 November 1946, Castle Hayne, New Hanover Co.; (2) yg. ♂, 7 December 1947, Hampstead, Pender Co.; (3) ad. ♀, 5 February 1947, Old Dock, Columbus Co.; (4) ad. ♂, 6 November 1948, Clinton, Sampson Co.; (5) ad. ♂, 9 October 1950, Burgaw, Pender Co. In addition, there were two living raccoons taken in Brunswick County in 1954 and kept in the city park in Wilmington for some months; they also were of this color phase. These data, and reports on about ten others which I did not examine, indicate that raccoons of this color phase are found occasionally throughout the entire southeastern coastal plain of North Carolina.

J. J. Flora, fur buyer at Moyock, Currituck County, informed me (*in litt.*) that he had bought three raccoons of this color phase during the 1960 trapping season. Most of his fur comes from southeastern Virginia and northeastern North Carolina. He inventoried 11,526 raccoons during the past trapping season. Ken Wilson, in charge of predator control for the North Carolina Wildlife Resources Commission, told me that he had never seen a raccoon of this description in 15 years of mammal investigations in northeastern North Carolina. For the past five years I have been in charge of preparation of specimens for the mammal collection at North Carolina State College, in Raleigh, and have seen well over 100 raccoons from the lower central Piedmont of North Carolina. All have been normal in coloration, and I have had no reports of abnormally colored raccoons in the Piedmont area.—JOHN B. FUNDERBURG, *Dept. of Zoology, Duke Univ., Durham, North Carolina.* *Received 6 April 1960.*

OBSERVATIONS ON THE CALIFORNIA SEA OTTER[1]

The major portion of these notes was collected from 4–15 September 1953, while filming the activities of the sea otter, *Enhydra lutris*. In part, these notes are supplemental to the accounts by Edna M. Fisher (J. Mamm., 20: 21–36, 1939; 21: 132–137, 1940). Observations were made on approximately 27 otters in the vicinity of Monterey Bay, Monterey County, California: at Yankee Point, Rocky Point, off Slates Hotsprings Baths, and at a point just north of Slates Hotsprings.

Food and feeding habits.—Sea otters were observed to feed on the red abalone (*Haliotis rufescens*), the sea urchin (*Strongylocentrotus franciscanus*), purple-hinged scallops (*Hinnites gigantea*)—a sessile scallop as an adult, the California mussel (*Mytilus californianus*) and various species of snails. It is possible that they also fed on the giant chiton or gumshoe (*Cryptochiton stelleri*). Numerous other unidentifiable animals were used as food.

All feeding was accomplished while the otters were lying on their backs, utilizing the chest and abdomen as a floating table. Females shared their food with juveniles and possibly with the males. The adults continually washed their food by rolling in the water,

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[1] This paper, based on research notes maintained by the author prior to his death, has been organized by Howard M. Feder, Hartnell College, Salinas, California. Arthur Kelly, Scripps Institution of Oceanography, J. B. Phillips, California Department of Fish and Game, and Paul Johnson and Janet Stearn, Hartnell College, assisted in the preparation of the final draft.

Conrad Limbaugh, chief diving officer at Scripps Institution of Oceanography and one of the world's foremost underwater naturalists, had been working on numerous and diverse research projects before he met his untimely death in a diving accident in the Mediterranean, on 20 March 1960. Many of his projects, including this one, were left unfinished although his intention to finish this particular work has been indicated in a statement found among his papers. Because of the extensive field notes and photographic records he maintained, it is anticipated that the results of most of his studies can be assembled and eventually published so the vast wealth of his accumulated knowledge will not be lost. —H. M. F.

the food clasped tightly against them with their forepaws. Occasionally the food material was pounded against a rock balanced on the abdomen; this action fractured the hard parts and made the internal organs of sea urchins and scallops available. Apparently pounding and fracturing of abalone shells permitted the otters to feed on the soft parts more readily. Sometimes, prior to feeding on abalone, an otter would balance the foot of the mollusk on its chest while it licked the shell clean. The foot and internal organs were removed from the shell and eaten, generally in a leisurely fashion. Small abalones were eaten directly from the shell. When the otter was through with a shell, it was discarded by dropping it to one side or by rolling over.

Rocks used as feeding aids were 2½ to 3½ inches in diameter, but sometimes flat ones as large as 6 inches in diameter were observed. Most food items were pounded against this rock held on the chest or abdomen; possibly other objects were pounded with the rock. Sometimes the same rock was carried on a series of successive dives.

Dives lasted from 60 to 90 seconds, frequently being made in a quick series to obtain a large abalone. Feeding occurred in shallow water, usually less than 3 feet, but sometimes as deep as 15 feet. The food organisms were removed from the rocks with the forepaws, often with the hind legs protruding out of the water while the otter attempted to dislodge its food in shallow water.

General habits.—A dive always began with the otter raising its head high, diving forward, and thrusting its hind legs clear of the water. During the dive a large number of air bubbles would rise to the surface. The dives were completed in a small area while feeding. However, dives made while traveling from one place to another were performed in sea-lion fashion: swimming face down while ducking the head forward just beneath the surface, and arching the body in an "S."

Swimming was accomplished by the otters in several ways: by paddling their hind feet while floating on their backs, by paddling their hind feet while lying face down, or by undulating their bodies from side to side. Sometimes the slender tails protruded from the water while the otters were swimming. Most travel by groups or individuals was along the inner edges of the bull whip kelp (*Nereocystis*) beds, which were extremely thick during the period of observations.

The otters seemed to have rather definite feeding areas and paths. Resting areas also remained fairly constant. After morning feeding the otters retired in small, sociable groups to a patch of giant kelp (*Macrocystis pyrifera*) and fall asleep while floating on their backs. Young otters spent considerable time cleaning and preening their fur. One adult was observed cleaning himself with a piece of seaweed.

When the young were awake, they played with other young and occasionally with adult male otters. They appeared to derive great enjoyment from sneaking up behind an old male and pulling him underwater while he fed or slept. Playing consisted of ducking and wrestling. If a youngster was getting the worst of the play, he would emit a cry similar to that of a sea gull. At this sound, the mother otter grasped him by the shoulders and carried him away from the play area. One otter was observed playing with a floating stick.

Whenever a young otter became separated from its mother, it uttered the same type of cry emitted by a playing otter in trouble. When the female heard this cry, or when she was concerned by a long absence of her young one, she stretched her head out of the water and peered in all directions, finally located the youngster, and swam directly toward it.

At the time of these observations the young otters were probably still nursing, judging from the swollen and red appearance of the two mammary glands of the females with young. Mammary glands of the sea otter, incidentally, are almost human in placement, but proportionately smaller.

Sea otter vision appeared to be good; their hearing seemed exceptionally fine. They could hear and locate an operating motion-picture camera from a distance of 100 yards. Occasionally a female was seen to take a male by the shoulders and pull him underneath

the water when he moved too near the photographers. The male was possibly a juvenile or a mate.

Otters apparently were undisturbed by the presence of the harbor seal (*Phoca vitulina*), but were quite concerned with the appearance of a California sea lion (*Zalophus californianus*). They demonstrated their fear by actively looking above and beneath the water when a sea lion was swimming nearby.

Methods of locating these animals.—Several guides are helpful in locating active sea otters. (1) Watch for ripples or wake marks made by swimming animals. (2) Search for sea gulls that might be hovering over otters in hope of recovering food scraps dropped during the feeding ritual. (3) Listen for the sound of shells being pounded against rocks by feeding otters. (4) Listen for the gull-like cry of the young otters. (5) Watch for the unusual presence of large numbers of sea urchin (*Strongylocentrotus franciscanus*) tests on the shore, many containing fragments of fresh tissue and bearing spines still in motion. This is an indication of sea otters feeding nearby. (6) Examine areas in or near kelp beds. —Conrad Limbaugh, *Scripps Institution of Oceanography, Univ. of California, La Jolla.* *Received 3 October 1960.*

[Publication of this paper was aided by a grant from The Permanent Science Fund of the American Academy of Arts and Sciences and by The Conrad Limbaugh Memorial Fund.]

THE FEMALE OF *MUSTELA FRENATA TEXENSIS*

To my knowledge the female of *Mustela frenata texensis* Hall has never been described. Therefore, a specimen (TCWC No. 6550) collected by Norbin Taylor at Del Rio, Val Verde County, Texas, 5 May 1960, is of more than passing interest. This specimen has the general color pattern of *M. f. frenata*, but the skull is larger in most respects as compared with Hall's measurements (Univ. Kansas Publ. Mus. Nat. Hist., 4: 426, 1951) of females of that race. It is on the basis of these measurements that I have assigned the female from Del Rio to the race *texensis*.

Following are cranial measurements of this specimen, with the largest comparable measurement of five females of *frenata* recorded by Hall in parentheses. Note that 14 of the 18 measurements exceed the known upper limits of *frenata* females.

Basilar length of Hensel, 45.5 (47.3) mm; length of toothrows, 17.2 (16.2); breadth of rostrum, 12.8 (12.5); interorbital breadth, 11.7 (12.2); orbitonasal length, 15.2 (14.6); mastoidal breadth, 25.4 (23.8); zygomatic breadth, 29.5 (27.0); length of tympanic bulla, 15.8 (14.3); width of tympanic bulla, 8.7 (7.5); depth of bulla, 3.7 (3.3); length of first lower molar, 6.0 (5.9); length of upper molar, 2.4 (2.2); width of upper molar, 4.8 (4.4); lateral length of Pm^4, 6.3 (5.5); medial length of Pm^4, 6.2 (5.7); depth of skull at anterior border of basioccipital, 14.9 (14.0); depth of skull at posterior border of molars, 13.3 (14.0); weight of skull (without mandibles), 3.1 (3.3) gm.—William B. Davis, *Dept. of Wildlife Mgt., Texas A. and M. College, College Station.* *Received 25 July 1960.*

FOOD HABITS OF A CAPTIVE LEAST WEASEL

On 15 April 1960, an adult male least weasel, *Mustela rixosa* Bangs, was captured in the basement of the Natural Science Building on the Michigan State University campus by Max Hensley. The weasel was kept in a small cage $8 \times 8 \times 16$ in. for nearly two months, during which period it was fed 28 mice (mostly white laboratory mice, *Mus musculus*) and 6 white rats (*Rattus norvegicus*) having a gross weight of 1,122.0 grams. The capturing, killing and general feeding behavior of a captive weasel are adequately described by Llewellyn (J. Mamm., 23: 439–441, 1942). The killing of a *Peromyscus* by a least weasel is also recorded photographically in *Sports Afield*, 142 (4): 84–88, 1959.

An indication of the relatively high energy requirements of the least weasel is given by the following feeding data. At irregular intervals the weights of the food consumed (weight

of the animal fed to the weasel minus the weight of the uneaten remains), of the weasel, and of the accumulated feces were obtained. The elapsed time between weighings varied from 19 to 94 hours. The average weight of the weasel computed from 34 weighings was 57.3 grams. Between consecutive weighing periods, the weight of the weasel should increase if more food than is necessary for maintenance is eaten, or should decrease if relatively little food is consumed, all other factors remaining equal. Food consumption rates that produced less than a 2.9 gram weight variation (5% of the 57.3 gm average weight) between weighing periods were arbitrarily considered to be maintenance rations. A rate of food intake that caused more than a 2.9 gm weight increase, between consecutive weighing periods, was considered to be greater than maintenance and a food consumption rate that resulted in a loss in weight of more than 2.9 grams between consecutive weighings, was considered to be sub-maintenance. The weight changes recorded on consecutive examinations on 16 occasions were less than ± 2.9 grams. On eight occasions, the average sub-maintenance food consumption rate with one S. E., was 0.66 ± 0.20 grams per hour, and on 8 occasions a greater than maintenance food consumption rate averaged, with one S. E., 1.17 ± 0.29 grams per hour. From these data it appears that a maintenance requirement for this least weasel, in captivity, was about one gram of suitable food per hour. The greatest observed rate of food consumption was 1.87 grams per hour, for a 25-hour period, which resulted in a 5.5-gram weight increase. It appears quite proper to calculate food consumption on a gram per hour basis, since the weasel was observed to have an intermittent feeding period throughout the day and night.

Certainly the least weasel in the wild is much more active than when in close confinement, so the relationship of the food requirement of the wild least weasel and of the captive animal is not equal. The average weight of six adult *Peromyscus maniculatus* trapped in April 1960, in Ingham Co., was 14.6 grams and the average weight of four subadult *Microtus pennsylvanicus* trapped in the same locale at the same time was 32.3 gms. If 1 gram per hour is considered as the minimum maintenance requirement of a 50–60-gram least weasel in the wild, then it must eat nearly one-half its body weight daily, a value equal to 1.6 *Peromyscus* or 0.75 *Microtus*. Llewellyn (*op. cit.*) determined that a 32-gram least weasel could consume 20 grams of mouse per day in captivity. Allen (J. Mamm., 21: 459–460, 1940) lists feeding data for four least weasels captured as juveniles and reared until adult-like in appearance. From his data, each weasel consumed about 1.3 mice per day. The mice were mostly house mice but a few *Microtus* were included. The gram weights of these mice were not included so the consumption rates in grams per hour cannot be calculated.

The defecation rate is a second indication of the relatively high metabolic rate of this small carnivore. In an elapsed time interval of 617 hours, 448 fecal deposits weighing 39.0 grams were recovered. On four occasions a partially eaten mouse was removed from the cage, stained with burnt sienna, and reintroduced into the cage. Then the times when the dyed mouse was eaten and when a dyed fecal deposit was first observed were recorded. The passage of a feeding through the digestive tract of the weasel, as measured by this crude marker, required between 138 and 270 minutes and averaged 203 minutes. Generally, feces were deposited at one end of the small cage and the remnants of the food were consistently located at the other end. More thorough studies of the least weasel in non-captive conditions to determine its food habits, coupled with more thorough studies in captivity to determine its metabolic demands, should yield interesting information about this smallest member of the Carnivora.—Henry L. Short, *The Museum, Michigan State Univ., East Lansing.* *Received 18 July 1960.*

BASSARISCUS ASTUTUS IN WYOMING

On 18 October 1957, at a place 3 miles north and 24 miles west of Kemmerer, 6,300 ft, Lincoln County, Wyoming, an adult male ringtail, *Bassariscus astutus arizonensis*, was found dead on U. S. Highway 30 N by Kenneth Demick. The ringtail, subsequently pre-

pared as a study specimen in the Zoology Museum of the University of Wyoming, is the first one of the species known from Wyoming and provides the northernmost known occurrence of the subspecies *B. a. arizonensis*, extending its known range approximately 112 miles northwestward from Dry Fork, 12 miles NW Vernal, Utah (see Hall and Kelson, THE MAMMALS OF NORTH AMERICA, Ronald Press, New York, p. 879, 1959). Hall and Kelson have shown the geograhpic range of each of the three subspecies, *arizonensis*, *nevadensis* and *flavus*, to extend to within 100 miles of the southern boundary of Wyoming. The Wyoming specimen agrees with *arizonensis* in having a dark face and brownish-gray upperparts. It lacks the gray spot immediately anterior to the ears and the paler upperparts characteristic of *nevadensis*. The Wyoming specimen differs from *flavus* in being smaller, having a darker face, and lacking dark-brownish color dorsally and buff laterally. Therefore, we have assigned the Wyoming specimen to *B. a. arizonensis*.

Unfortunately, the skull of this specimen was crushed and only portions of it, including the unworn, complete dentition, were preserved. External and cranial measurements are as follows: total length, 734 mm; length of tail, 365; length of hind foot, 23; ear (from notch), 37; alveolar length of maxillary toothrow, 28.1; alveolar length of mandibular toothrow, 32.2.—CHARLES A. LONG AND H. BRADFORD HOUSE, *Museum of Natural History, Univ. of Kansas, Lawrence.* *Received 21 June 1960.*

PARTIALLY ALBINO BADGER FROM CALIFORNIA

Albinism is apparently rare in all species of carnivores. Among the many cases of albinism reported in this journal during the last twenty years, only two have involved carnivores. Green reported on albino coyotes, *Canis latrans* (J. Mamm., 28: 63, 1947) and Allen and Neill mentioned albino raccoons, *Procyon lotor* (J. Mamm., 37: 120, 1956). For this reason the following specimen may be of interest.

A partially albino female badger, *Taxidea taxus*, was picked up as a fresh road kill on 23 November 1959, by Jack Johnson of the California Department of Fish and Game. It was found about 2 miles northeast of Pine Canyon Guard Station on California State Highway 166, in Santa Barbara County, along the Cuyama River. The specimen (Plate I) weighed 8 pounds 12 ounces and had the following measurements: total length 650, tail 132, hind foot 94 mm. The skull was too badly crushed to be saved.

This badger was generally cream-colored, with pale cinnamon legs, feet and head markings, and had a cinnamon wash over the dorsal surface, most pronounced posteriorly. The tail was cream-colored. Close examination showed that all hairs that normally have a black subterminal band were instead marked only with cinnamon, the remainder of the hair being creamy white. Hairs on the face and legs, normally black or dark brown distally,

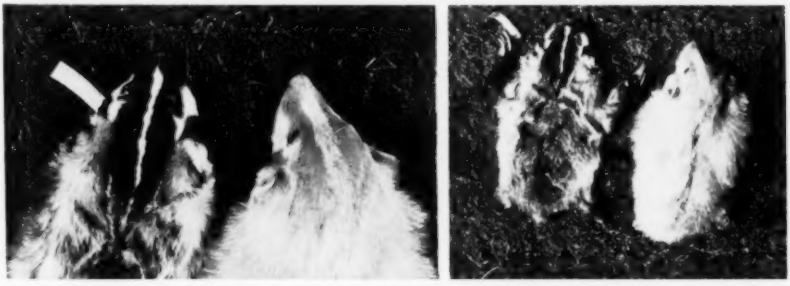

PLATE I

Comparison of partially albino and normally pigmented badgers. Although dark melanins are completely absent in the albino, pale reddish ones are still obviously present. Normal specimen was taken 6 August 1954 at Walker Pass, Kern County, California.

were cinnamon. Claws and nose pad were light tan, while the eyes, as well as could be determined, had been light-colored in life.

Grinnell, Dixon and Linsdale (FUR-BEARING MAMMALS OF CALIFORNIA, 1937) mention a similarly colored badger that was collected 31 May 1913, in Marin County, describing it as follows: "All parts of the pelage which in the normal badger are dark brown or blackish are in this abnormal one pale reddish brown. There is no dark pigment of any sort in the coat." They also report such a condition for a specimen of spotted skunk, *Spilogale putorius*, collected in 1919 near Firebaugh, Madera County. This pale reddish condition may be akin to a mutation known in house mice as "cinnamon," which involves the absence of dark melanins (Sinnott, Dunn and Dobzhansky, PRINCIPLES OF GENETICS, 1958).

The specimen was prepared as a cased skin and is now in the California State Polytechnic Colloge collection.—ARYAN I. ROEST, *California State Polytechnic College, San Luis Obispo. Received 15 June 1960.*

CURIOSITY BEHAVIOR IN SOME MUSTELIDS

While working as a ranger-naturalist in Yellowstone National Park, Wyoming, I observed curiosity behavior in the marten, *Martes americana*, the long-tailed weasel, *Mustela frenata*, and the badger, *Taxidea taxus*.

My encounter with a marten occurred on the shore of a small lake at the foot of a talus slope. I glanced up and saw a marten watching me, about 50 feet away under a large boulder. I continued walking but kept glancing at the marten, which continued to watch me. I changed direction and began to climb slowly over the talus toward the marten. Several times, as I approached, the marten motioned as if to move away, but each time I stopped and the marten held its position. When I had approached to about 25 feet, the marten jumped down out of sight. I stood still and within 2 minutes the marten reappeared. This sequence was repeated three more times until I was about 9 feet away, when the marten finally disappeared among the rocks. This activity seemed to be a mixture of fear, or a tendency to flee, and of curiosity. The ambivalence in activity can be understood in terms of change of stimuli. Movement toward the animal stimulated flight so that the threshold for flight was lower than that for curiosity, and the animal started to leave. But my standing still lowered the stimulus for flight, and curiosity behavior was reasserted. Berlyne (*in* W. H. Thorpe, LEARNING AND INSTINCT IN ANIMALS, p. 95, 1956) postulated that the difference between fear and curiosity resided in the intensity of the stimulus. This field observation seems to support such an hypothesis. Similar observations of boldness and curiosity were reported by Halvorson (J. Mamm., 42: 111, 1961) and by Manville (*ibid.*, 42: 112, 1961).

My encounter with a long-tailed weasel occurred at Sheepeater Cliffs in northern Yellowstone National Park. As two companions and I approached the cliffs, we saw a weasel running across the talus, carrying a mouse. The weasel disappeared in the rocks. Presently it reappeared without the mouse, ran across the rocks and stopped and stared at us. Then it disappeared behind a large boulder, emerged with the mouse, ran to a flat rock at the edge of the talus and crawled beneath it. We approached the rock and could hear the weasel crunching on the mouse. I lifted the rock and the weasel dashed off without the mouse. However, it climbed on a rock about 40 feet away and looked back. I took a position against a tree about 9 feet from the mouse; my companions stood about 15 feet to my right. The weasel began to explore the area around me, looking and sniffing in all directions. He then circled and approached my companions. The weasel, still cautious, approached my companions, put his forelegs up on one of them, sniffed, and then ran back to the rocks. A few minutes later he behaved the same with me, then dashed from the rocks and stood over the mouse. Suddenly he departed, but without the mouse. This sequence was repeated, but the third time the weasel picked up the mouse and ran off among the rocks. Such boldness has been reported by Hansen (J. Mamm., 33: 492, 1952).

I had one encounter with a badger that displayed curiosity. While driving along the park highway, I observed a badger in a sagebrush flat. When I parked the car and walked toward the badger, it ran to a burrow and entered. I stopped about 20 feet from the burrow; the badger stuck its head out and watched me. I again approached and the badger immediately withdrew. It was about 2 feet down in the burrow and hissed at me when I looked in. I then walked about 18 feet away; after a few moments, the badger stuck its head out and watched me. It did not emerge any further and I left shortly thereafter.

The boldness and curiosity displayed by these small carnivores appear to be a form of exploratory behavior, a type of behavior that may be a primary activity, such as eating and sleeping (S. O. Barnett, New Biology, 27: 70–86, 1958).—KENNETH B. ARMITAGE, *Dept. of Zoology, Univ. of Kansas, Lawrence.* *Received 18 April 1960.*

A WEST VIRGINIA PUMA

Members of the University of Virginia Cave Club, led by Roger Stafford, explored Higginbothams Cave No. Four, 1.3 miles west of Frankford, Greenbrier County, West Virginia, in August 1959. In the cave, between 2,000 and 3,000 feet from the only known entrance, the party found the skeleton of a large cat. To reach this spot the cavers had crawled 450 feet over rock and through liquid mud in a passage 16 to 24 inches high and had waded through water 4 feet deep. The skeleton lay on the surface of a mudbank, 30 feet above a subterranean stream, apparently in the position in which the animal had died (Plate 1).

On subsequent trips to the cave, E. H. Geil, W. K. Nelson and Roger Stafford collected the skeleton, and later sent it to the National Museum. Unfortunately the bones were soft and crumbly and had largely disintegrated before they reached the museum.

Simpson (Amer. Mus. Novit., 1131, 1941) has reported the jaguar, *Felis onca*, as a Recent or sub-Recent inhabitant of Appalachian caves. The only other known large cat of eastern North America, the puma, *Felis concolor*, was last collected in West Virginia perhaps a hundred years ago (Kellogg, Proc. U. S. Nat. Mus., 84: 456, 1937). The identity of this specimen is therefore of considerable interest.

The skeleton proves to be that of a puma. It is smaller than the Pleistocene puma, *Felis inexpectata* Cope (= *F. longicrus* Brown and *Smilodontopsis mooreheadi* Hay; see Simpson, Amer. Mus. Novit., 1136, 1941) and thus must be considered to be the Recent *Felis concolor couguar* Kerr (Table 1). The bones and teeth match closely those of a skeleton of *F. c.*

PLATE I

Skeleton of a puma, *Felis concolor couguar*, as it was found in Higginbothams Cave No. 4 in West Virginia. (Photo by W. K. Nelson.)

TABLE 1.—*Measurements (in mm) of teeth of Pleistocene and Recent pumas*

Species and source	P^4 length	P^4 width	P_4 length	P_4 width	M_1 length	M_1 width
Felis concolor couguar:						
Higginbothams Cave No. 4 (USNM 314838)	22.3	12.5	15.6	8.4	17.8	8.3
Capon Spr., W. Va. (USNM 848)	23.4	11.4	–	–	–	–
Felis concolor coryi:						
Collier Co., Fla. (USNM 265596)	24.5	13.3	16.8	8.7	18.1	9.0
Felis inexpectata (from Simpson):						
F. inexpectata holotype	24.0	–	–	–	–	–
F. longicrus holotype	27.3	13.4	–	–	–	–
Smilodontopsis mooreheadi holotype	26.9	–	–	–	–	–
Cumberland Cave, Md. (USNM 11890)	26.6	12.2	17.2	9.1	20.9	9.6
Conard Fissure, Ark. (AMNH 12398)	–	–	17.1	8.9	20.0	9.2

couguar from Capon Springs, West Virginia (USNM 848).—CHARLES O. HANDLEY, JR., *U. S. National Museum, Washington 25, D. C.*, ROGER STAFFORD AND EARL H. GEIL, *Univ. of Virginia, Charlottesville.* *Received 20 July 1960.*

THE LATEST SPECIMEN OF THE EASTERN PUMA

The survival of a remnant of the long-supposed extinct eastern puma, *Felis concolor couguar*, was first reported by me in 1948 (J. Mamm., 29: 235–246). My findings were amplified in 1953 (Canad. Field-Nat., 67: 12–28). Since then an intensive search has been carried out to secure a specimen for study. This specimen has now been obtained, and it is believed to be the last taken in the Northeast.

It was trapped by the late Rosarie Morin of St. Zacharie, P. Q., east of Little St. John Lake (46° 06′ N, 70° 16′W) in Somerset County, Maine, in January 1938. This is the date given by Joseph Alexandre. However, Mr. Fernand Prévost of Quebec City, a schoolmate and close friend of Alexandre, puts the date at 1935 or 1936 by his own age and the age at which he left school. He did not see the specimen, but he heard about it from Alexandre. Mr. Morin brought the skin back to his home in St. Zacharie, where it was acquired by the village priest. He sent it to Quebec to be mounted. Upon his death it became the property of his heir, who sold it to the Northeastern Wildlife Station.

Further evidence of the eastern origin of this specimen is furnished by a report from Jonas Bros. of Denver, Colorado, that it was mounted raw, not tanned in the usual manner. They refused to attempt to remount it for this reason. The fact that a raw puma skin was delivered to the taxidermist in Quebec City is strong supporting evidence of its local origin.

Plate I shows the position in which the animal was mounted. The following measurements were made from the specimen in this position: total length over curves, 7 ft 1 in.; tail length, 3 ft; estimated height at shoulder, 1 ft 8 in.; estimated weight, 100 lb. The genitals had been removed, but the medium-large size, small nose pad and small head indicate it was probably a female. Some hair was missing and there was some fading, but no sign of the usual black and white facial markings or eye stripe. The right upper canine was missing (pulled out after mounting); the molars were present and not worn. These facts, and the sharp condition of all claws (except those in the trap), indicate an adult in the prime of life. The specimen was of the red color phase—a uniform red-brown, darker dorsally and lighter ventrally, with a black tip to the tail. The hair back of the ears was nearly rubbed off, but the remaining hair was dark red-brown, not black. The animal had been trapped; the two front claws of the left hind foot were missing and there was a trap mark across the toes.

PLATE I

The Little St. John Lake specimen, an adult female (?) in the red color phase, trapped in January 1938.

The specimen has been placed in the collection of the Northeastern Wildlife Station at the University of New Brunswick. The last specimen known to be taken in this region was shot at Mundleville, Kent County, New Brunswick, in March 1931. It was not preserved and the photograph appearing in my 1953 paper is all that remains for the record. The last complete specimen to be preserved in the Northeast is apparently that killed near Barnard, Vermont, on 24 November 1881. This specimen advances the date by 57 years.

The writer is indebted to Wildlife Technician Jacques Normandin of the Quebec Fish and Game Department who located the specimen and helped materially in tracing its history.—Bruce S. Wright, *Northeastern Wildlife Station, Univ. of New Brunswick, Fredericton.* *Received 6 June 1960.*

BISON BISON IN NEVADA

Remains of the modern bison, *Bison bison*, seem not to have been recorded from Nevada up to now.

Figure 1 shows the left horn core and part of the front of a skull from long. 116° 38′ 27″ W and lat. 39° 34′ 16″ N at 6,720 feet elevation on Water Canyon Creek at its junction with a man-made diversion ditch (for irrigation), on the southeastern side of the Simpson Park Mountain Range in Lander County, Nevada. Concerning this skull Mr. Peter J. Damele of Dry Creek Ranch, Eureka, Nevada, on 8 January 1960, wrote me as follows:

"The skull was found by my father, Peter L. Damele, a 67 year old cattle rancher, in 1955. While riding for cattle on the Simpson Park Mountain Range he noticed one horn of what he thought must be 'an awfully old cow skull.' The horn and a small part of the skull had been uncovered by a small ditch deepened by the spring runoff; the remainder of the skull was covered by about 10 or 12 inches of sod and willows. He almost left it

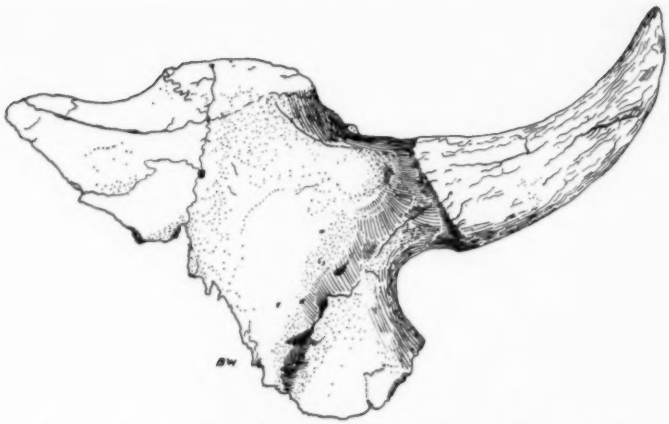

FIG. 1.—*Bison bison athabascae* from Lander County, Nevada. × ¼.

there, but reasoned (and considerable credit must be given him for his observance of this) that a cow skull with a horn as big at the base as this one was would be much longer. My brother Benny who accompanied him at the time dug it out with his spur."

Selected measurements are as follows: tip of the horn core (in a straight line) to the junction of the interparietal bone and two parietal bones, 300; greatest circumference of the horn core, 248; length of the horn core on its dorsal surface measured along the curve, 196 mm.

The considerable curvature of the horn core and robust features of the preserved part of the skull give basis for identifying the specimen as *Bison bison athabascae* Rhoads. The specimen is in the possession of Mr. Peter J. Damele.—E. RAYMOND HALL, *Museum of Natural History, University of Kansas, Lawrence. Received 30 June 1960.*

ADDITIONAL RECORD OF MOUNTAIN GOAT IN NORTHEASTERN WASHINGTON

Dalquest (Univ. Kans. Publ., Mus. Nat. Hist., 2: 409, 1948) mentions a single record of the mountain goat (*Oreamnos americanus*) for northeastern Washington. He also states this mammal is "seemingly a rare wanderer from outside the state."

During September 1958, H. C. Moon of Metaline Falls, Washington, discovered the remains of two yearling mountain goats near a campground at Sullivan Lake, Pend Oreille County, Washington. About the same time woodsmen working in the area noted that the mountain goats occasionally seen along the Red Bluff Trail on the west side of Sullivan Mountain were no longer present. It is likely that the goats were illegally shot and their remains discarded near the campground.

Ralph Johnson, Washingtion State Game Protector, recovered the skulls which are deposited in the Colorado Cooperative Wildlife Research Unit collection, Colorado State University, under acquisition numbers 812 and 813.—DONALD R. JOHNSON, *Forest and Range Management Section, Colorado State Univ., Ft. Collins. Received 29 August 1960.*

TWO SOUTHERN RANGE EXTENSIONS IN CHIHUAHUA

Recent collections from Chihuahua, Mexico, made by field parties from the Museum of Vertebrate Zoology have considerably extended the known range of two species of mammals. In view of considerable current interest in Mexican mammals, it seems desirable to place these specimens on record.

On 11 June 1957, one adult specimen of *Myotis subulatus* (MVZ No. 121706) was collected by Victor Lewin 5 miles N Chihuahua, 4,700 ft, Chihuahua, Mexico. This extends the known range about 220 miles toward the southeast from Llano de las Carretas, 27 miles W Cuervo (MVZ No. 74803), the nearest locality in northwestern Chihuahua, and 160 miles westward from Terlingua Creek, Brewster Co., Texas (Davis, J. Mamm., 25: 201, 1944). The specimen seems referable to the subspecies *melanorhinus* because of its rich dorsal coloration and buffy wash on the ventral surface. Since specimens from west Texas have been placed in the subspecies *subulatus* (Davis, *op. cit.*), this new record probably represents an extension of range from northwestern Chihuahua. Pertinent measurements (in mm) recorded from this specimen are: total length 81, tail length 37, hind foot length 7.7 (dry), ear length 11, forearm 33.5, and third metacarpal 31.9.

A young adult (PM and M^3 newly erupted) female specimen of *Perognathus intermedius intermedius* (MVZ No. 122994) was collected by the author on 26 June 1958 at 1.5 miles N Boquilla de Conchos, 14 miles SW Cd. Camargo, Chihuahua, Mexico. The specimen was collected on a rocky slope just north of the dam which forms Lago Toronto, and hence is from the north side of the Rio Conchos. This extends the known range over 90 miles to the south-southeast of Chihuahua City, the previous southernmost locality (Osgood, N. Amer. Fauna 18: 53, 1900), and suggests that the species range continues south at least to the north shore of the Rio Conchos. Diagnostically important measurements (in mm) are hind foot length 21, ear length 7.5, cranial length 23.1, and rostral width 2.5.—William Z. Lidicker, Jr., *Museum of Vertebrate Zoology, Univ. of California, Berkeley.* *Received 31 August 1960.*

DISTRIBUTION RECORDS FOR MAMMALS IN WEST-CENTRAL QUEBEC

During the summers of 1957 and 1958, small mammal population studies were carried out by the senior author in an area to the south of Clova, Quebec. Specimens for identification were collected from study plots located within a 10-mile radius of the confluence of the Gatineau and Chouart Rivers (lat. 47° 50′ N, long. 75° 35′ W). Identifications were verified by the junior author through comparison with specimens in the collection of the National Museum of Canada.

The vegetation of the region was predominantly jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), with white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*) common species on the ridges. About 30 miles to the south, elements of the Great Lakes–St. Lawrence forest region (Rowe, Forest Regions of Canada, Bul. 123, Can. Dept. N. Aff. and Nat. Res., 1959) become predominant.

The capture of the following species presents marginal records for the distributions as reported by Hall and Kelson (The Mammals of North America, Ronald Press, New York, 1959):

Blarina brevicauda talpoides (Gapper).—This species was not very common in the area. Eleven individuals were captured, of which eight were taken in a single trapline. Hall and Kelson quote Bark Lake (Bole and Moulthrop, Sci. Publ. Cleveland Mus. Nat. Hist. 5: 83–181, 1942) as a marginal record for this species in Quebec. This lake is about 70 miles southeast of the study area.

Myotis keeni septentrionalis (Trouessart).—Two specimens were taken in an old stable located 26 miles south of Clova.

Tamiasciurus hudsonicus ungavensis Anderson.—The specimens collected are intermediate between *ungavensis* and *laurentianus* but are decidedly closer to the former, especially in dorsal tail coloration. This area is about 130 miles southeast of the type locality of *ungavensis* at Lake Waswanipi.

Peromyscus maniculatus maniculatus (Wagner).—The study area is probably in a zone of intergradation between *maniculatus* and *gracilis*. The specimens are intermediate between the two, but are decidedly closer to *maniculatus*. This species was taken in a variety of habitats; it was the most abundant species on hardwood ridges but was rare in dense stands of middle-aged and mature jack pine.

Clethrionomys gapperi hudsonicus Anderson.—The specimens examined show some intergradation with *gapperi* but are referable to *hudsonicus*. This was the most abundant species in mature jack pine stands but was uncommon elsewhere.

Napaeozapus insignis abietorum Preble.—The specimens captured are definitely referable to this race. Some intergradation with *algonquinensis* might have been expected, but there was no evidence of it. This species is apparently rare in the area.

Other species captured in the area are as follows: *Sorex cinereus cinereus* Kerr, *Sorex palustris albibarbus* (Cope), *Microsorex hoyi intervectus* Jackson, *Condylura cristata cristata* (Linnaeus), *Tamias striatus quebecensis* Cameron, *Phenacomys ungava ungava* Merriam, *Microtus pennsylvanicus fontigenus* Bangs, *Synaptomys cooperi cooperi* (Baird), and *Zapus hudsonius canadensis* (Zimmerman).

This is contribution No. 638 of the Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.—C. F. MacLeod, *Forest Biology Laboratory, Canada Dept. of Agriculture, Quebec,* and A. W. Cameron, *Redpath Museum, McGill Univ., Montreal.* *Received 22 April 1960.*

NEW LOCALITY RECORDS OF SOME KANSAS MAMMALS

For the past 15 summers, field parties from the University of Michigan Museum of Paleontology have been collecting in Kansas. In the course of their field work, many specimens of Recent mammals have been obtained. Some of these further prescribe or extend the range of the species or add to our knowledge of their habits. All specimens are in the mammal collections of the University of Michigan Museum of Zoology. I wish to thank Dr. C. W. Hibbard for making available the specimens and data.

Lasionycteris noctivagans (Le Conte).—The field party has for a number of years used an old CCC foreman's building at the Meade County State Park. At the end of a field season numerous small items including burlap sacks and newspapers for wrapping fossils are stored in two small closets in the building. The closets have no ceiling, but open directly into the attic. There is an open ventilator into the attic at each end of the building. In the past, individuals of *Peromyscus* and *Mus* have moved into the building in the fall and winter and have made nests in the papers and sacks.

Late in August 1958, at the close of the field season, approximately 36 snap-traps, baited with raisins, were set throughout the building. In June 1959, all traps but two were sprung, and 32 of them contained mice. A trap in one closet contained a silver-haired bat, *Lasionycteris noctivagans*; in the other closet there was a silver-haired bat beside a sprung trap. The bats apparently stopped during their late fall migration and entered the closets, possibly for warmth. Late fall is considered as the time the bats were caught, since they were well dried and there was no damage from flies or other insects. The two specimens (Nos. 109906 and 109907) were preserved as skeletons. The attic of this and another building were searched, but no other bats were found.

Tadarida brasiliensis mexicana (Saussure).—Byron Walker, an employee at the Meade County State Park, discovered a few Mexican free-tailed bats hanging to the screen of an office window the morning of 19 August 1946. He made up three or four skins and donated one (No. 95831 ♀) to the University of Michigan.

Dasypus novemcinctus mexicanus Peters.—In the spring of 1950, H. W. Paske shot an armadillo near his farm 2½ miles north and ⅜ mile west of Toronto, Greenwood County, Kansas. The animal was seen by Charles E. Hibbard, who arranged for it to be given to the University of Michigan. The specimen is an adult (No. 103460 ♂) and is in the alcoholic collection.

Vulpes fulva fulva (Desmarest).—Lee E. Bowmaker, a science teacher at Glasco High School in Cloud County, Kansas, captured two male red fox pups from a den 1½ miles southwest of Glasco, in the spring of 1959. The den was situated high in the bank of a tributary to the Solomon River. The pups were given to his niece, Lisa Dufield of Kismet, Kansas, who donated them to the University of Michigan (Nos. 109957 and 109958).

Urocyon cinereoargenteus (Schreber).—A male gray fox was caught by Earl Ford in a coyote set, 8 April 1956, 14 miles southwest of Meade, Kansas. Ford tanned and kept the skin but donated the skeleton (No. 103536) to the University of Michigan.

Francis Cochran of Meade, Kansas, in the spring of 1959, recovered the skull and lower jaws of a freshly killed gray fox on U. S. Highway 283, 2½ miles north of its junction with U. S. Highway 160 in Clark County. The locality is 9½ miles south of Minneola. The specimen was donated to the University of Michigan (No. 109956).

Urban and Wimmer (J. Mamm., 40: 450, 1959) reported the occurrence of the gray fox in Cimarron County, Oklahoma, approximately 145 miles southwest of the Meade County record. It is not known whether the western Kansas individuals reached the area from the western or the southeastern populations of the gray fox, but it is of interest to note the spread of this species into the plains region.—Lowell L. Getz, *Museum of Zoology, Univ. of Michigan, Ann Arbor.* *Received 11 April 1960.*

A CONVENIENT METHOD OF CARRYING AND DISPENSING BAITS

Collectors who must alternately set traps and write field notes are frequently disconcerted to find their notes or clothing smeared with bait. This may be eliminated by filling an ordinary plastic catsup squeeze-bottle with bait that has been made into a thick paste. The nozzle of the squeeze-bottle should be cut off so that the hole is about ¼ inch in diameter.

Peanut butter may be dispensed without alteration, but a small amount of corn oil or cottonseed oil may be added to liver-sausage and other baits which are too viscous to be easily squeezed from the bottle. One full bottle will bait several hundred small mammal traps.

Finely mashed sardines with oil and a few drops of commercial fox lure added makes an excellent bait for most carnivores and opossums, and can be dispensed easily from squeeze-bottles. One full bottle will bait 75 to 100 large mammal traps.—B. J. Verts, *Illinois Natural History Survey, Urbana.* *Received 11 July 1960.*

You are needed to complete the roundup of mammalogists at the University of Illinois, 12–15 June, for the Society's 41st Annual Meeting.

REVIEWS

Jackson, Hartley H. T. MAMMALS OF WISCONSIN. Univ. Wisc. Press, Madison. Pp. xiv + 504, 81 maps, 220 halftones, 154 line drawings. 10 February 1961. Price, $12.00.

Jean Nicolet, the first European to visit Wisconsin, landed at Green Bay in 1634; here, at feasts given by the Indians, his party was served "at least sixscore beavers." In 1673, Louis Joliet recorded a puma in what is now Grant County. In time, the fur trade moved into Wisconsin where, by 1850, there were at least forty trading posts. Our knowledge of the mammals of the state dates from the observations of the early missionaries, explorers and trappers. Much of this early lore, plus a vast amount of information accumulated since, is here recorded in an attractive and impressive volume. Assembling it has been largely a labor of love, for the author, himself a native of Wisconsin, put up his first study skin there as a boy not yet in his teens. The project had its formal start in 1917 with the first of a series of field surveys, jointly sponsored by the State of Wisconsin and the U. S. Biological Survey, which collected in all 71 counties of the state, under the supervision of the author. In the course of preparing this book, over 6,300 Wisconsin specimens were examined, as well as 30,000 from elsewhere in the United States in 31 public and private collections. Analyzing this material and collating it with observations and accounts in the literature was the sort of task for which the author is peculiarly fitted.

Dr. Jackson, as readers of this journal are aware, has made a career of mammalogy. In 1910 he joined the U. S. Biological Survey, serving with such men as Vernon Bailey, A. K. Fisher, E. A. Goldman, A. H. Howell, E. R. Kalmbach, C. H. Merriam, E. W. Nelson, T. S. Palmer, E. A. Preble and W. P. Taylor. He continued with this organization and its successor after 1940, the U. S. Fish and Wildlife Service, until retirement in 1951. But since then he has not been idle, as attested by the present book. His writings include *North American Faunas* 38 and 51, on moles and shrews, two books, and more than 900 articles, technical papers and reviews. In 1918 he helped to organize the American Society of Mammalogists, and served as its corresponding secretary from 1919–24, editor from 1925–29 and president from 1938–39; in 1952 he was elected to honorary membership. Happily, he continues active in the field and at the office, where his counsel and companionship are cherished by his many friends and colleagues.

Considered in this book are 84 species and subspecies of mammals, as well as 4 not yet verified from Wisconsin; type localities of 15 of these are in Wisconsin, and 8 of them were described by Jackson. Introductory material deals with the history of mammalogy in the state, physiographic and ecological features, and suggested aids to study. The systematic treatment following contains appropriate keys, occasionally to species level, for identifying the Wisconsin fauna. Each account contains a brief synonymy and paragraphs on vernacular names (the author has chosen his own preferences with care), identification marks, measurements, distribution in Wisconsin, habitat, status and habits, list of Wisconsin specimens examined, and about six of the most important references. Dental formulae are given, and extensive treament of life histories, behavioral characteristics, breeding habits, mortality factors, abnormalities and economic aspects. Particular effort has been made to include data on parasites, diseases, home ranges, populations, seasonal color changes, mutations, means of intercommunication, and other matters often overlooked in other manuals. Appropriate extracts of some length are made from other publications. The author's special interest in the subject has led to the inclusion of pertinent bits from Indian legends and early pioneer folklore; these are carefully selected, charming pieces which add perspective and nicely supplement the technical accounts. A useful bibliography of 47 pages indicates the extent of the author's meticulous research. A good 20-page index completes the volume.

The well-chosen illustrations depict nearly all phases of the subject. Each species is represented by at least one good photograph. Line drawings show the teeth of shrews, wings of bats, oil gland of muskrat, palate of vole, skull of coyote, an otter's den, chipmunk's burrow, and the gnawing of a gray squirrel, among other items, as well as the foot-

prints and scats of all species. On the maps are shown record stations in Wisconsin as well as the range in North America; some maps also contain such information as population trends, present and past distribution, and hunter and trapper kills.

This is a large book (7½ × 10½ in.) set in two-column format. It has been carefully edited and proofread. The printing is good, the typography clear, the binding sturdy. Not only professional biologists, but all those with an interest in wildlife, will find it a valued addition to their libraries. Authoritative as it is, and with such a comprehensive coverage of details, its usefulness will surely extend far beyond the bounds of Wisconsin. The author and publisher deserve commendation for a thoroughly excellent job. Mammalogists will use it with gratitude and will find in it a high standard for work still to be done in other areas.—RICHARD H. MANVILLE.

Niethammer, Günther, *Ed.* REPORTS AND RESULTS OF BAT-BANDING EXPERIMENTS IN GERMANY AND AUSTRIA. Bonner zoologische Beiträge, Sonderheft, Jahrgang 11, 263 pp., illus. 22 December 1960.

All those with an interest in bats will welcome these 22 papers, in German, on investigations from 1951–59. Findings on the growth, longevity, habits and travels of bats, obtained primarily from banding records, are presented by 24 workers in Germany, though their subjects ranged widely over Europe. The bat-banding program was started in the United States by Arthur A. Allen in 1916; large-scale projects began here in 1932, and records have been centralized in Washington, where those of Canadian and Mexican bat-banders are also consolidated. In the lead article of this series, "Bat-banding, its development, techniques and significance in scientific research," Martin Eisentraut summarizes the arrangements for bat-banding in 17 European countries. These date from 1932 in Germany and from 1936 in France and The Netherlands. The present tome clearly indicates the vigor with which European workers have applied themselves to these problems.—R. H. M.

Borror, Donald J. DICTIONARY OF WORD ROOTS AND COMBINING FORMS. N-P Publications, Palo Alto, Calif. 134 pp. 15 September 1960. Price, $2.00 (paper).

Medical students, taxonomists and biologists as a whole are confronted with a vast and often puzzling array of technical terms and names with roots from the Latin, Greek and other languages. Those most frequently encountered are brought together here by Dr. Borror, of the Department of Zoology and Entomology, The Ohio State University. An introductory section explains how to use the dictionary and contains also a useful guide to the pronunciation of scientific names. The word list itself comprises 104 pages. Supplementary material deals with the formulation of scientific names, the translation of Greek words, and a good number of common combining forms. This manual should prove very helpful both to those trying to master the scientific language and those proposing to add to it.—R. H. M.

Parkes, A. S., *Ed.* HYPOTHERMIA AND THE EFFECTS OF COLD. British Medical Bull., Vol. 17, No. 1, pp. 1–78. January 1961. Price, $3.25.

This entire issue is devoted to a symposium of 14 papers by British workers in this rapidly advancing field. Modern investigation of hypothermia in man dates from the work of Fay and Smith, in 1938–39. It became important as a complicating factor in survival at sea, during World War II. More recently, there has been emphasis on its clinical use as a surgical tool. Much of this material particularly concerns physiologists, physicians and surgeons. It contains original contributions as well as reviews of significant work in the field. Of special interest to mammalogists are the articles by L. Harrison Matthews on *Hibernation in mammals and birds*, by J. S. Hart on *Physiological effects of continued cold*, and by F. Depocas on *Biochemical changes in acclimation to cold*.—R. H. M.

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COMMENTS AND NEWS

41st ANNUAL MEETING

Our 1961 meetings will be held at the University of Illinois, Urbana, from 12–15 June. Details appear in the February issue, page 143. Plan to be present, enjoy the companionship of your colleagues, and present a paper on your mammalogical research.

LITERATURE FOR LATIN AMERICA

There is an increasing demand from Latin American libraries for scientific books and journals. The Pan American Union calls attention to means for distributing such literature and invites American scientists to consider donating their surplus or unused files of scientific and technical journals for this purpose. The value of such gifts, plus mailing charges, is income tax deductible. The central clearing house is the U. S. Book Exchange, a nonprofit corporation with a total membership of 2,500 libraries and information centers throughout the world—1,400 in foreign countries and 365 in Latin America. More than one and one-half million items are exchanged annually and thousands of further requests are being received. Here is an opportunity for cleaning out our attics while performing a really useful service to foreign workers. Further information about the program may be obtained from the U. S. Book Exchange, 3335 V St. NE, Washington 18, D. C., or from the Division of Science Development, Pan American Union, Washington 6, D. C.

NORTH AMERICAN FAUNAS

A few old issues of the *North American Fauna* have been found and will be made available to interested parties. They are Nos. 37 (Howell, Marmots), 42 (Cary, Wyoming life zones), 56 (Howell, Ground squirrels), 58 (Neff, Band-tailed pigeon), 59 (Goldman, Arizona pocket gophers) and 60 (Goldman, Raccoons). Only one copy of each issue per customer, as long as supply lasts. Address requests to the editor. Orders for more recent issues of the *Fauna* should be addressed to the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

AVAILABLE B & M SERVICES

Members may be interested in the services available from The Literary Division, Biological and Medical Services, 1003 Myra Avenue, Yeadon, Pennsylvania. This organization is equipped to handle all-language translation from and into English, literature searching, preparation of slides and films, abstracting and indexing, and general redactory, publication and mailing service in biological and related fields. Cost estimates and further details will be supplied on request.

DEATHS REPORTED

Larry R. Commissaris, 17 January 1961

Walter J. Scott

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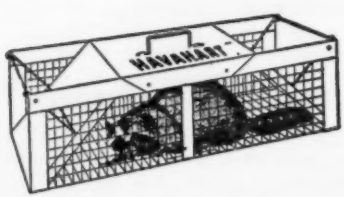

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